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Primary teacher professional learning in the Maldives:

An explorative study of science process skills pedagogies

Aminath Shiyama

School of Education, University of Bristol

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Abstract

The teaching of science process skills (SPS), such as observing, measuring, hypothesising, and investigating, are integral to school science education and with constructivist pedagogies, those SPS can be taught with contextual contingencies. This study is focussed on the context of upper primary schools in the Maldives, where science is taught by generalist teachers. The aim of this study was to work in collaboration with those teachers to explore a contextually contingent approach to teach SPS in upper primary schools. The collaboration, informed by social learning theories, was designed as a form of continuing teacher professional development that allowed insights into teachers' professional learning for teaching SPS. Hence, exploring SPS pedagogies and teacher professional learning in tandem offers a nuanced view into the contextual contingencies of these practices.

An epistemological view of social-constructivism was adopted to explore the intricate and subjective processes of teacher learning. A participatory teacher research methodology comprising of two phases of data collection and analysis was adopted as the research methodology. In the first phase, interview data from 14 generalist primary teachers was used to identify widespread practices of SPS pedagogies and teacher professional development. Focus group interviews with teacher educators and curriculum developers provided contextualisation for these practices. Findings from the first phase informed development of the second phase of data collection. The second phase engaged four generalist primary teachers in professional learning activities over a period of six months; the intervention focussed on the planning and implementing of inquiry-based investigation approaches as a form of SPS pedagogies. Acting as both professional learning facilitator and researcher, I gathered data through individual interviews, classroom observations, and group meetings; supplementing them with our co-developed teaching resources, and teacher-led classroom-based research inquiry. For this phase, narrative, thematic data analysis was conducted and combined with findings from the first phase, which provided a richly textured and complex picture of SPS pedagogies and teacher professional learning.

When generalist teachers instruct science classes, the SPS pedagogies that they can practice are variations of formalist pedagogies and progressive constructivist approaches. These seemingly opposite teaching strategies create tension between the enactment and experiences of the SPS pedagogies prescribed in the curriculum. Further, applying a social learning lens to teacher professional learning offers a contextually-situated understanding of the micro-processes and the micro-dynamics of teachers' learning, pedagogical praxis, professionalism, and the incessant challenges in teaching outside of one's specialism. These findings add to the existing empirical base that argues against 'one-size-fits-all' educational practices that are emblematic of uncritical borrowing in global education. Thus, this study highlights that SPS needs to be flexibly defined and taught as an integrated set of skills which are applied in learning the content of science using contextually sensitive pedagogies. In order to support generalists who are teaching science outside of their specialism, professional learning that is centred on their classroom is critical. Additionally, this study emphasises the importance of contextually contingent practices of professional development and pedagogical praxis; an approach that allows for flexibility and differentiation in teacher learning. Finally, this study highlights the crucial role of local researchers in bringing contextual realities and sensitivities to the forefront of comparative research.

Dedication

To my children, Ayaan & Amaan, your presence in my life make me strive to do and be a better person. I love you unconditionally.

&

To my late brother, Adam, your absence in my life has not diminished your encouragements that motivate me to learn. I miss you every day.

This is for you.

Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's *Regulations and Code of Practice for Research Degree Programmes* and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such.

Any views expressed in the dissertation are those of the author.

SIGNED: Aminath Shiyama **DATE**: 26 November 2020

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List of Abbreviations

Acronym	Long name/form
ADB	Asian Development Bank
CD	Curriculum Developer
IGCSE	International General Certificate of Secondary Education
LCE	Learner-centred Education
LMIC	Lower-middle-income country
LT	Leading Teacher
MNU	Maldives National University
MoE	Ministry of Education
NIE	National Institute of Education
OBE	Outcomes Based Education
OECD	Organization for Economic Cooperation and Development
PD	Professional Development
SIBA	Science-investigation-based approach
SIDS	Small Island Developing State
SPS	Science process skills
TALIS	Teaching and Learning International Survey Teacher
TE	Teacher Educator
TIMMS	Trends in International Mathematics and Science Study
TPL	Teacher professional learning
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
WB	World Bank

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Chapter 1. Introduction

> Once a flame has been started, its shape and chemical composition can be varied without extinguishing it. To this extent, its identity is not defined by its physical or chemical topography, but by the operational principles which sustain it.
>
> (Polanyi, 1958, p. 406)

Learning science is not just about remembering content; rather, it is about becoming a scientific inquirer, learning to do and to talk science (Bianchi & Booth, 2014; Dawes, 2004; Hodson, 1999; Rivard & Straw, 2000). Hence, the development of science process skills (SPS) such as observing, measuring, formulating hypotheses, interpreting data, and experimenting (Aydoğdu, 2015; Özgelen, 2012; Padilla, 1990) should be integral to science learning. These skills equip students for scientific inquiry and learning, problem-solving, and creative and critical thinking They are skills that are increasingly recognised as valuable in a global context of fast-paced change and uncertainty, driven by climate change and technological development (Allchin, 2014; Bangay & Blum, 2010; Trna, Trnova, & Sibor, 2012). The pedagogic strategies for supporting students' development of a full or integrated set of SPS tends to be a niche area of expertise limited to those teachers who are science education specialists. However, in the context of primary education in many countries, including the Maldives, primary science education is undertaken by generalist teachers who may not have acquired the science content knowledge and associated pedagogies to be able to teach SPS; they may struggle to use constructivist pedagogies which promote the nature of scientific inquiry. Such a limited 'palette' of pedagogies calls for the provision of teacher professional learning opportunities that engage teachers practising a variety of SPS pedagogies.

A common conception of teacher learning as teacher professional development (PD) favours transmissive and one-shot traditional models of professional learning (Kennedy, 2016). Teacher professional learnings (TPL) are both formal and informal, focus on individual learning as well as learning within a community of teachers, and consider the progressive nature of learning itself. This dynamic, communal form of professional learning support can be facilitated through a research-based understanding of how teachers conceptualise and organise their teaching to enhance students' understanding of SPS together with the scientific concepts being taught (Loughran, Milroy, Berry, Gunstone, & Mulhall, 2001). The support mechanism for teacher PD also takes into consideration that teachers' needs and capacities shape a pedagogical praxis that is contextually contingent (Schweisfurth, 2015).

Based on these theoretical and conceptual considerations, I sought to explore two aspects of SPS pedagogies and TPL. In the first stage, I worked to capture the status quo of generalist teachers' conceptualisations and practices of SPS pedagogies and teacher PD. In the second stage, I then developed TPL activities to engage and map the evolution of teachers' SPS pedagogies and to determine how such learning engagement brings about professional learning. In so doing, this research illuminates potential and possible pedagogical practices as well as viable TPL mechanisms for application within the Maldivian context.

Section 1.1 Rationale for the study

The rationale of the study is presented below in three parts; the general, contextual and personal rationale.

1.1.1 General rationale

Internationally, research has highlighted that students' science learning experience which incorporates SPS is integral to learning science because these skills can foster students' critical, creative, and ethical thinking (Archer et al., 2010; Downing & Filer, 1999; Millar, 2010; Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003), while enhancing problem-solving and decision-making skills (Trna et al., 2012). Since the 1980s, a large body of research has advocated for the use of progressive constructivist pedagogies such as learner centred education (LCE) and LCE-based inquiry-learning. However, comparative educational studies (Crossley, 2010; Guthrie, 2020; Schweisfurth, 2013b; Sriprakash, 2010; Tikly, 2019) have demonstrated that these pedagogies need to be contextually relevant and appropriate. Furthermore, for generalist primary teachers, teaching science LCE pedagogies is challenging, since their limited conceptual understanding of science is magnified by their limited pedagogical 'palette'. Thus, teacher professional development and learning opportunities can support generalist teachers to cultivate a variety of pedagogical tools and practices that they can employ.

The literature on PD highlights the importance of teachers' in-service learning, not only to improve students' learning outcomes (Darling-Hammond, Hyler, & Gardner, 2017; Hattie, 2012) but also as a critical aspect of teacher professionalism (Day & Sachs, 2004; Evans, 2011). In this research, teacher PD is explored from teachers' perspectives as a way to support and establish their pedagogical praxis (Fitzgerald & Smith, 2016; Loughran, 2013; Smit, Gijsel, Hotze, & Bakker, 2018). For teachers of science, PD that is connected to pedagogical praxis of science is meaningful if the learning opportunities are situated in their classroom contexts. However, there is dearth of literature which specifically explores how generalist primary teachers develop their pedagogical praxis for SPS through PD and learning activities. Furthermore, there is serious lacuna in research which explores science teaching professional learning for generalist primary teachers in the Maldives. Such a pedagogical inquiry is critical to understand how generalist teachers can be supported, developed, and valued in science education (Childs & McNicholl, 2007), and a contextualised exploration could illuminate the contextual contingencies associated with such practices. As such, **the general rationale** for this stud**y** is to collectively address the aforementioned research areas in SPS pedagogies and teacher professional development in order to understand the relevance of progressive constructivist pedagogies in teaching SPS.

1.1.2 Local rationale

The **local rationale** for this study is significant. The Maldives, a Small Island Developing State (SIDS), considered amongst the world's lower- middle-income countries (LMIC), is one of the low-lying countries in the world. Located in South-Asia, the Maldives has a strong history of conservative learning approaches attributed to its long tradition of formalistic Islamic education (Adam, 2015b; Di Biase, 2017; Shareef, 2016). According to the Maldivian constitution, every Maldivian must practice Islam; thus, every child's formative education begins with Islamic Education, characterised by formalistic pedagogical practices, such as rote-learning.

In 2015, the Maldivian government introduced an outcomes-based-education (OBE)[1] curriculum that maps formal school education from grades 1 to 12 (students from the age of six years to 18 years) onto skills and competencies (for example, 'practising Islam', 'thinking creatively and critically', and 'using the technology and media' (NIE, 2015b). This curriculum was developed by the Ministry of Education

[1] Outcome-based-education (OBE) is often used interchangeably with competence-based-curriculum CBC), given the subtle difference between them (Jansen, 1998; Morcke, Dornan, & Eika, 2013).

(MoE), with support, consultation and aid from a variety of foreign agencies[2]. One of the reasons for the Maldives to adopt an OBE curriculum with its associated LCE progressive education ideals (Guthrie, 2018) is that its design has been used in countries such as Australia and the UK; the Maldives – rightly or wrongly, tends to look to these nations as models of a 'good education' practice. Although both countries have now shifted away from the OBE orientation[3], the Maldives, like other LMICs (for example, Rwanda in Africa and the Dominican Republic in the Caribbean) has continued moving towards OBE curricula. Formalistic pedagogies tend to be considered 'unscientific' (Cobern, 1996; Le Grange, 2007), so the introduction of OBE stands to correct this issue. With the historical legacy of a religious-based education system which promoted formalistic pedagogies (Guthrie, 2020), the introduction of a progressive OBE curriculum provides a fertile basis to explore the pedagogical relevance of teachers' practices and how they make meaning with these dual – and perhaps duelling – approaches.

A corpus of literature argues against uncritical borrowing of educational practices and pedagogies labelled as 'global best practice' because doing so may ignore contextual sensitivities (Crossley, 2010) such as the country's (poor) economic situation (Barrett, 2007) or their longstanding pedagogical traditions (Klees et al., 2020; Schweisfurth, 2013a). In this curriculum 'shift' in the Maldives, there is little evidence presented in the curriculum documents on how the curriculum design was contextualised and adapted to the Maldivian context, implying heavy uncritical borrowing from curriculum design practices that advocate for progressive LCE pedagogies in all school subjects including science.

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[2] For example, WB, UNDP, and Cambridge Assessment International Education

[3] Due to a series of backlashes over how OBE promotes superficial learning or demarcates learning to observable behaviours.

In the primary science education component of the current national curriculum in the Maldives, considerable emphasis is made on developing students' SPS, prescribing their pedagogical application using constructivist pedagogies that are derived from progressive LCE ideals. In the highly centralised education system that currently exists in the Maldives, questions arise regarding the feasibility, practicality, and enactment of progressive constructivist pedagogies. Further, in primary schooling, when generalist teachers are required to teach science when their science content knowledge and associated pedagogical palette is limited, teaching SPS using constructivist pedagogies becomes challenging (Childs & McNicholl, 2007; Turford & Turner, 2018). Further, it has been reported that, in the Maldives, primary teachers' science teaching is characterised by traditional practices of content-laden teaching, examination-driven instructions and memorising content of science, limiting students' understanding and application of science skills (Shareef, 2016).

Similarly, primary teachers' professional development and learning practices and opportunities in the Maldives tend to be limited to one-shot workshops that often have been reported as lacking relevance to their pedagogical praxis (Naseer, 2018; Saeed, 2008; Saeed & Moreira, 2010). As Barrett, William, and Richard (in press) argue, there is limited practical value in promoting specific pedagogies via the curriculum or similar, without exploring how teachers within the context can learn and practice them. Thus, professional learning is an integral process that serves a dual process; for teachers to adapt the curriculum prescribed pedagogies to expand their pedagogical repertoire, and for the curriculum to modify its prescriptions based on teachers' collective experiences from implementing these pedagogies. Therefore, a contextually contingent approach to understand and develop teachers' practices is critical for both pedagogical innovations and promoting democratic teacher professionalism (Kelly, 2006; Sachs, 2016). Such practices take into account the historical, political and socio-cultural context of the local, alongside global and international research literature and education policy deliberations (Crossley, 2010; Crossley & Sprague, 2012; Di Biase, 2016, 2019).

Internationally, there is limited research on how generalist primary school teachers develop their pedagogic practice in the context of reform to OBE. Further, in the Maldivian context, there is also limited studies on how generalist teachers engage in professional learning that is centered around their pedagogical praxis of SPS. As such, this research offers a snapshot into the Maldivian context which suggests possible pedagogical practices and changes to teach SPS as a process of professional learning through which generalist teachers can learn, develop and adapt their pedagogical repertoire in teaching science. Further, this research also offers professional learning practices that are reflective of teachers' contextual and situated professional learning needs.

1.1.3 Personal rationale

My **personal interest** in this topic comes from my experience as a science educator in the Maldives. I have been working as a teacher educator and curriculum developer for primary school science, at the Maldives National University (MNU) since 2005. I am a passionate advocate for progressive constructivist pedagogies (such as LCE) in science education; I attribute some of this enthusiasm to my studies in higher education gained outside of the Maldives.

In my practice of observing primary science teaching, I noticed a dominance of formalistic teacher-centred, content-focussed, exam-oriented pedagogical practices amongst both pre-service and in-service teachers. Especially in the teaching of science, I had noted teachers' SPS pedagogies were limited despite our pre-service and in-service PD targeted specifically at strengthening teaching of SPS in the new curriculum. It seemed that primary teachers' science teaching had removed all forms of hands-on activities that make science learning exciting. These observations and sentiments were noted and shared amongst my teacher education and curriculum development colleagues.

Thus, I was concerned and wondered why primary teachers were not implementing LCE pedagogies in teaching science and SPS, as specified in the curriculum and as emphasised in our in-service trainings. If these pedagogies were not useful, what other relevant pedagogies could generalist primary teachers easily adopt and use in their science teaching and simultaneously be aligned with the curriculum prescriptions? I wondered whether primary teachers were exposed to alternative pedagogical approaches in their professional development activities and what forms of professional learning would be meaningful for science teaching in the Maldives. These professional observations and reflections motivated me to pursue a PhD to seek answers to these questions. My passion for science and love for science education, further motivated this endeavour.

Therefore, in this thesis, I attempt to better understand primary teachers' existing practices of SPS pedagogies and how teacher professional development and learning could support teachers' pedagogical practices for teaching SPS.

Section 1.2 Research aim, objectives, and research questions

The **research aims** to explore Maldivian upper primary (Grades 5 to 6) teachers' professional learning of pedagogies for science process skills. The following six **research objectives** were articulated to achieve this aim.

1. Critically review the international literature on primary school pedagogies with a focus on science process skills pedagogies and the literature on teacher professional development and learning.
2. Provide an overview of the socio-historical and cultural context of science education and teacher professional development and learning in the Maldives.
3. Explore how teachers, teacher educators and curriculum developers within a primary science education context in the Maldives conceptualise and teach science process skills and teacher professional learning.
4. Explore and develop science process skills-based pedagogies and associated curriculum resources for science education in Grade 6, in collaboration with four classroom teachers.
5. Draw out implications for policy and practice on primary science education in the Maldives.
6. Contribute to the academic debates around science education pedagogies and teacher professional development and learning.

Towards achieving these objectives, the empirical work of this research was designed to address the following **research questions**:

1. How do primary teachers in the Maldives conceptualise and support their students to develop science process skills and its pedagogies?
2. What pedagogies for science process skills are possible and meaningful for primary teachers in the Maldives?
3. How can a professional learning inquiry engage primary teachers in exploring and enhancing their pedagogies for science process skills?

Section 1.3 Overview of the theoretical framing

Two sets of theories are adopted in this study. Firstly, theories of constructivist learning are applied to understand and explore **pedagogies for science process skills (SPS)**. Secondly, social learning theories are applied to understand and explain **teacher professional learning** (**TPL)**. The implication of using these two theories is, while pedagogies are developed for students' learning, teachers learn about these pedagogies through more professionally apt, socially mediated learning activities.

Constructivist learning theories are applied for SPS pedagogies for three reasons. Firstly, the National Science Curriculum of the Maldives advocates for using pedagogies based on constructivist learning theories. Secondly, science education scholars claim that using constructivist pedagogies for teaching SPS is appropriate for the development and understanding of process skills because such pedagogies help improve students' attitudes toward science (Aruna & Sumi, 2011; Aydoğdu, 2015). Thirdly, constructivist learning theories are well established and recognise the social dynamics of the classroom, and works to build on learners' pre-existing knowledge-base to constructively develop their understanding of science (Cakir, 2008). Constructivist learning theories broadly combine social-constructivist learning theory and cognitive-constructivist learning theory and in doing so view learning as a social enterprise facilitated by the individual's cognitive learning capabilities. As such, learning takes place through the interaction of learners' prior-experiences and current knowledge, guided through the learning situations and scaffolded by the teacher (Nola, 1997; Scaife, 2012). Further, the synthesis of cognitive and social constructivist perspectives is useful in learning science because these theories value learning as socially mediated, culturally sensitive, and personally constructed (Windschitl, 2002).

Although constructivist learning considers social dynamics in the process of learning, the paradigms proposed by this theory offer limited explanations for exploring teachers' professional learning processes. As such, social learning theories, as proposed by Wenger (1998), offer a better theoretical basis to explore and understand the multiple facets and the dynamic nature of how teachers learn and develop their pedagogical praxis. According to Wenger (1998), learning is produced through the active participation of its pursuit; learning progresses as a continuum as we make meaning, and from the unfolding learning experiences we engage in. Thus, TPL is about active participation in the exploration and development of shared pedagogical practices that are meaningful for teachers' as professionals. I applied Wenger's (1998) four dimensions; *community*, *identity*, *meaning*, and *practice* comprehensively in this study to understand, explain, and explore this social nature of teachers' professional learning engagements in exploring and adapting SPS pedagogies.

Thus, in this study, constructivist learning theories provide the lens to explore possible SPS pedagogies in the primary science education in the Maldives, and social learning theories provide a secondary lens to view and understand possible professional learning practices for generalist primary teachers in the Maldives. These two theories are applied in tandem towards achieving the aim of this thesis: to explore upper primary teachers' professional learning of pedagogies for SPS.

Section 1.4 Overview of the philosophy and methodology

This research is positioned within a socio-constructivism epistemology informed by a subjectivist ontology of SPS pedagogies and teacher professional development and learning. As such, teachers' experiences and practices of SPS pedagogies and professional development and learning are explored, assuming that these 'realities are apprehended in the form of multiple, intangible mental construction, socially and experientially […] dependent for their form and content on the individual persons or groups holding the constructions' (Guba & Lincoln, 1994 pp. 110-111). Such an epistemological lens is consistent, coherent and compatible with the theoretical framing of this study enabling the exploration of contextually contingent pedagogic approaches for developing SPS in primary schools in the Maldives, together with the processes associated with developing and implementing a professional learning engagement through which generalist teachers can be supported to teach SPS.

From this epistemology, a participatory teacher-research methodology was adopted for this study. Key to this methodology is the collaboration between researcher and teachers, requiring the active participation of all personnel involved in constructing valued representations of teachers' practical knowledge of pedagogies and professional learning (Elliott, 1994). This methodological approach was applied to support the structure of a two-phased sequential design for this study where participatory methods of were employed to gather qualitative data.

Within the sequential approach to participatory research, I began with an exploratory phase to identify the status quo of teachers' pedagogical and professional learning practices; this phase was followed by the design and implementation of professional learning inquiry which was centred around a pedagogical inquiry into science-investigation-based approach (SIBA) to teaching SPS. In the first phase, I employed teacher interviews prompted by their students' work samples to identify SPS pedagogies, participants' discourse around the curriculum-prescribed pedagogies, and their experienced pedagogies. These discourses were compared and contrasted with interview data from curriculum developers and teacher educators where the findings pointed towards teachers' practice of SPS pedagogies, their limited opportunities for professional learning, and the need for contextually contingent approaches for a pedagogical inquiry. Based on these findings, I designed a bespoke professional learning inquiry focussing on SPS pedagogies, comprising multiple learning opportunities spanning a six-month period. Over this period, there were multiple sources of data gathered, including classroom observations, teacher interviews, and co-developed teaching resources and reflection exercises; all of these sources contributed to a rich, deep, and unique understanding into how generalist teachers develop their SPS pedagogical praxis through professional learning that is meaningful for them individually and as a part of teacher communities.

Section 1.5 Structure of the thesis

This thesis is comprised of 10 chapters. The current chapter has introduced the study with an overview of the research topic, the rationale, aims, and objectives. Chapters 2 and 3 address the first objective of this research. **Chapter 2** reviews the international literature on SPS pedagogies to support the theoretical framing relevant to this study. **Chapter 3** is focussed on the literature around teacher professional development and learning; including the theory that I used to make meaning of and, to understand TPL. The theories presented in Chapter 2 and Chapter 3 are consolidated at the end of Chapter 3. **Chapter 4** addresses the second research objective, by problematising and contextualising science education and teacher professional development and learning in the Maldives. **Chapter 5** explains the research design and process. The methodological basis for this study is presented here, including details of the structure of this study and associated data collection methods. Issues of researcher positionality, reflexivity, research trustworthiness, procedural and situational ethics are also discussed.

Chapters 6-8 present the findings from this research. **Chapter 6** presents findings from the first phase of data collection to provide an understanding of the status quo of teachers' pedagogical practices of SPS and professional development and learning. Chapters 6 and 8 address research objective four. **Chapter 7** presents the findings from the development and implementation of bespoke TPL activities to highlight which features were significant for both the teachers and the professional learning engagement. **Chapter 8** focuses on findings that illuminate the teachers' professional learning journeys and the pedagogical praxis of SPS.

Chapter 9 addresses research objective five by drawing on the findings from Chapters 6 and 8, and discusses how they answer the research questions. This chapter is comprised of two sections. Section 9.1 discusses findings from Phases One and Two of this study, exploring the contextual contingencies of SPS pedagogies. Section 9.2 focusses on discussing findings regarding TPL highlighting the nature, components and features of such learning.

Finally, in **Chapter 10**, I attend to the final research objective, following a summary of the answers to the research questions, I identify the implications for policy and practice. This chapter closes by identifying the key contributions from this research and the limitations of the study, along with suggestions for future research and a reflection on my own personal and professional learning from the research process.

Chapter 2. Science Process Skills Pedagogies

> The concept of 'pedagogy' recognises that there are some basic and fundamental understandings (or principles) about learning and teaching that can be 'known' and that this knowledge base can provide teachers with practical ideas that they can apply, test, adapt and develop according to the demands of the contexts in which they work.
>
> (James & Pollard, 2012, p. 1)

Introduction

This research aims to explore upper primary teachers' professional learning of pedagogies for science process skills (SPS). This chapter and the following chapter review the literature germane to this study. Here, I concentrate on literature to conceptualise pedagogies and discuss the theoretical framing I apply in this study; I then consider literature on primary science education and SPS pedagogies. This order is important here because the conceptualisation and theorisation of pedagogies can then be used to inform, explore and understand the relevant literature on SPS pedagogies.

As such, in Section 2.1, I review the literature in order to differentiate between 'pedagogy as practice' and 'pedagogy as praxis' to explain how I conceptualise and apply these concepts in this study. I present Nind et al.'s (2016) dimensions of pedagogies as a conceptual framework to understand and explore the contextually contingent processual nature of pedagogies and how each of the dimensions in this model impact such contingencies. In Section 2.2, I present constructivist learning theory to frame SPS pedagogies to consider the contextually contingent nature of learning. There, I also discuss some similarities and differences between progressive education and constructivist learning theories to identify how I distinguish them from each other in this study. In Section 2.3, literature on teaching SPS in primary education and the application of constructivist pedagogies for SPS are reviewed. Finally, in 2.4, the key argument of this chapter, generalist primary teachers' difficulties associated with teaching SPS is developed.

Section 2.1 Conceptualising pedagogy

In this section, I explore different conceptualisations of pedagogy and discuss their limitations to present at how I frame and apply the concept of pedagogy in this research. In this section I broadly conceptualise pedagogy using the metaphors– pedagogies as, science, craft, or art, to arrive at how it is defined in this study: pedagogy as ***praxis*** (as opposed to practice) and pedagogies as a ***process***.

2.1.1 Pedagogy as science, craft, or art

'Pedagogy' can be broadly defined using the metaphors: as a science, as a craft, or as the art, of teaching for learning (Alexander, 2004; Nind, Curtin, & Hall, 2016; Siraj-Blatchford, Sylva, Muttock, Gilden, & Bell, 2002). These metaphors provide us a litany of ways for viewing pedagogy and its associated roles (Nind et al., 2016). Literature on international education development policies, for example Education for All by UNESCO (1990) or the *Teach* tool produced by the World Bank (2019), view *pedagogy as* ***science*** because in this view, pedagogies are compressed into measurable, controllable, and managerial behaviours delineated by 'experts' (Galton, 2007; Nind et al., 2016; Sriprakash, 2012; Tikly, 2019). This reductionist approach to pedagogy subscribes to a 'one-size-fit-all' universal norm, fails to take into account contextual difference, and necessarily marginalises teachers' expertise (Steiner-Khamsi, 2013).

Instead, conceptualising *pedagogy as* ***craft*** considers the everyday practical knowledge of teachers and withholds judgements of 'effective pedagogy' (Nind et al., 2016), enabling us to explore pedagogy as 'knowledge carved out of and shaped by situations, knowledge that is constructed and reconstructed' (Clandinin, 1992, p. 125). Nind et al. (2016) believe that Shulman (1987) was referring to such forms of situational knowledge as teachers' pedagogical knowledge base[4]. However, Shulman (1986) argue that teaching (and thus pedagogy) is not a mere craft akin to a craftsman having the knowledge of 'how' to perform artisanal work, but teachers as professionals hold an *extra* knowledge of 'what' and 'why' with regard to their pedagogies. As such pedagogical knowledge is not simply knowing the craft of teaching, but also encompasses 'what' and 'why' are the justifications associated with teachers' pedagogical choices.

Finally, the metaphor of *pedagogy as **art*** 'involves appreciation of imagination, emotion, expression and creativity developed in the relationships forged in teaching and learning' (Shuman, 1986, p. 64). This metaphor allows us to consider the qualitative, subjective nature of choices and judgements within pedagogy. Pedagogies as ***art***, thus exist at the intersection and interaction of *pedagogy as **science*** and *pedagogy as **craft***, enabling a more broad and holistic view of pedagogy. This study conceptualises pedagogy as an art, which allows us to inductively theorise pedagogy from teachers' experiences in navigating complex social relations, power dynamics, and agency in their teaching contexts (Nind et al., 2016).

2.1.2 Pedagogy as praxis

Pedagogy as a ***praxis*** is a more comprehensive term than pedagogies as practice; 'practice' is a subset of praxis itself. Pedagogy as praxis considers the practitioner's individual and collective engagement, application, and refinement of theoretical ideas *through* practice (Haffenden, 2003) which is enabled and/or constrained through 'historically formed and transformed cultural-discursive, material-economic and social-political' discourses and norms (Smith, Edwards-Groves, & Kemmis, 2010, p. 5). Alexander (2004) defined pedagogy as 'what one needs to know, and the skills

[4] Schulman (1987) describes these knowledge base as: content knowledge; curriculum knowledge; pedagogical content knowledge; knowledge of learners and their characteristics; knowledge of educational contexts; and knowledge of educational ends, purposes, and values, and their philosophical and historical grounds.

one needs to command, in order to make and justify the many different kinds of decisions of which teaching is constituted' (p. 11) encompasses pedagogies as a praxis, rather than mere practice. In this sense, pedagogical praxis refers to multi-level engagement that is beyond mere repetitiveness of an action or type of actions. This approach considers teachers as active agents in the meaningful synthesis of theories of/on pedagogies to classroom experiences and allows us to explore teachers' roles and choices in the pedagogy they employ in their classrooms.

Using the metaphor of *pedagogy as **art*** allows us to embody pedagogies as praxis that valorises the importance of teachers' identities, their experience-based pedagogical frameworks of 'what works' (Galton, 2007; Siraj-Blatchford et al., 2002), and the political, cultural, and institutional contexts in which teaching and learning take place (Schweisfurth, 2013a), in conjunction with the theoretical basis of pedagogy that either stems from the content they are teaching or pedagogical approach they are using. Thus, my aim in this research is to use a constructivist epistemology of pedagogies to study the contextually contingent, processual, dynamic nature of the pedagogies (Nind et al., 2016; Schweisfurth, 2015) which surround and underpin science process skills (SPS) in Maldivian primary science classrooms, utilised by generalist teachers.

2.1.3 Pedagogy as process

Nind et al. (2016) proposed three inter-related dimensions of pedagogy: *pedagogy as **specified***, *pedagogy* as ***enacted***, and *pedagogy* as ***experienced*** (see Figure 2.1). This model refines the previous conceptualisations of pedagogies as art and pedagogies as praxis to allow a more nuanced view of the 'what' and 'how' of pedagogies. It also considers the interrelations where pedagogy is defined, practiced, negotiated, and translated from and between each dimension, highlighting its processual nature. As such, Nind et al.'s model considers the contextually contingent nature of both the planned and unplanned relationships and interactions (Galton, 2007) between teaching and learning and between teachers and students, (Loughran, 2013) to encapsulate the meaningful, collective experiences of teachers, the education system, and the milieu as a whole (Alexander, 2004). As such, defining pedagogy as a process provides us with a broader and more in-depth understanding to arrive at a definition of pedagogies as praxis. For these reasons, I employ this conceptual model to explore pedagogy for SPS in this study.

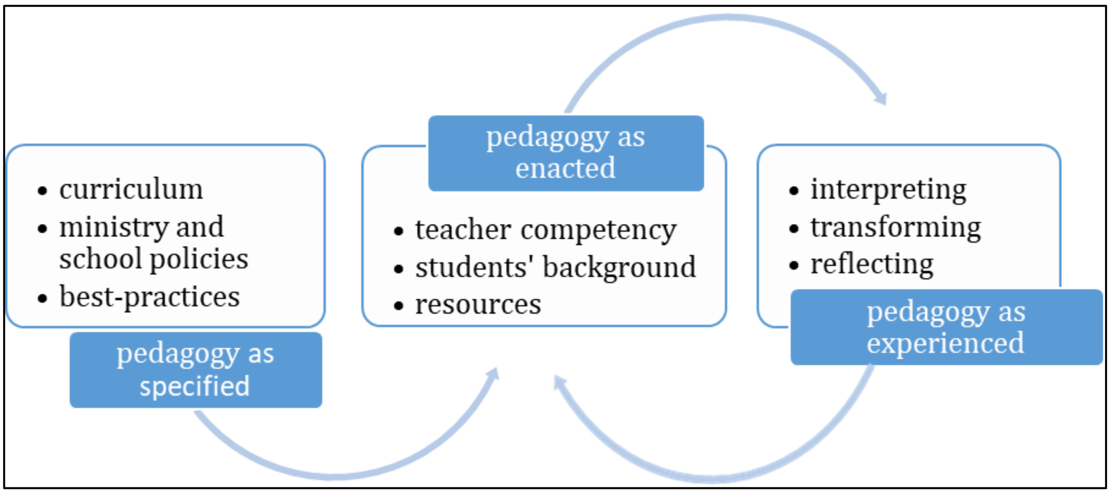

Figure 2.1 The three dimensions of pedagogy by Nind et al. (2016).

According to Nind et al. (2016), the first dimension (*pedagogy as prescribed*) focusses on 'what is assumed to be approprite knowledge' (p. 10) as determiend and informed by education policies, theory and 'best-practices'. As such, this first dimension presents itself as technical in nature, but it also provides the theoretical basis for how curricula advocate for different forms of pedagogy and why. In this research, the dimension of *pedagogy as **specified*** is embodied with the primary school science curriculum component in the Maldives National Curriculum and, in particular, the 'Working Scientifically' strand which specifies the key SPS to be taught. The pedagogies prescribed in the science curriculum are informed by theories of learning and definitions of SPS (such as observing, formulating questions, hypothesizing and investigating) which emerge from Ministry of Education (MoE) policies and mandates for primary school science (NIE, 2015a). According to the science curriculum, these SPS are to be integrated within science content, and pedagogies which emphasise inquiry-based approaches to learning pedagogies are to be used to teach SPS (NIE, 2011, 2015a). This dimension of pedagogy 'enables us to trace more explicitly the expectations and resources involved in a programme's implementation, often taken for granted by the imperatives of policy and programmatic reform' (Sriprakash, 2012, p. 12).

The second dimension (*pedaggoy as **enacted***) provides a view into 'how the enactor breathes life into the official version of pedagogy' (Nind et al., 2016, p. 10-11). In this study, the enacted dimension is found in the ways in which teachers interpret the pedagogies prescribed in the curricula for SPS and translate them into classroom discourse (such as teacher instructions, teaching resources, and activities) based on characteristics of their classroom context, such as students' backgrounds. The second dimension of pedagogy in this model allows us to consider the theory-practice elements of pedagogies as praxis in order explore and understand the subjective nature of pedagogies and the contextual attributes that shape it.

The third dimension (*pedagogy as **experienced***) relates how the actors (such as teachers and students) continually decode and interpret the pedagogy in the classroom: 'what' is happening and 'how' it is happening. Exploring the third dimensions allow a more nuanced socio-cultural approach to the processes of pedagogies that are experienced, negotiated, and realised by both teachers and students.

Taken all together, applying these three dimensions in this study allows exploration of how specified, enacted, and experienced pedagogies shape how SPS pedagogies are experienced by teachers in the Maldivian primary science classroom. In the next section, the theories used to explore pedagogies as applied to SPS are discussed.

Section 2.2 Theoretical framing of pedagogies: *Constructivist learning theory*

Teachers' decisions about classroom teaching and pedagogies are heavily determined by how they perceive and facilitate the learning experiences, which is in turn based on their understanding of the classroom context and the content that they are teaching (Fitzgerald & Smith, 2016; Gordon, 2009). Such constructions of learning are premised 'in a commitment to the idea that the development of understanding requires active engagement on the part of the learner' (Jenkins, 2000, p. 601). These notions are key tenets of constructivist learning theories. Often teachers are exposed to these forms of pedagogical practice through pre-service teacher education as well as through curriculum prescriptions (see Chapter 4 for discussion of curriculum in the context of Maldives). Constructivist learning theories further underpin science process skills pedagogies (for example, Cakir, 2008; Loughran et al., 2001), as I explore later in this subsection.

Contemporary constructivist learning theories can be attributed to the work of Vygotsky (1978), Piaget (1954), and Dewey (1929). Jenkins (2000) explained that Vygotsky's view on learning focussed on the socio-cultural elements that influence the process of learning, while for Piaget the process of learning depends on the biological, psychological, and cognitive functionings of the individual learner. As such, Vygotsky viewed learning as socially constructed while Piaget viewed learning as individually constructed. Dewey looked instead at learning within the environment: the learning context, the role of experience, and the manner in which learner communities shape and define the process of learning (Popkewitz, 2016). As such, Dewey's theories combined the work of constructs found in Vygotsky and Piaget; he argued that learning is socially mediated *and* dependent on the individual's cognitive processes.

Although these three theorists approach learning from different focal points, they all acknowledge that 'learners actively create, interpret, and reorganise knowledge in individual ways' (Gordon, 2009, p. 738). However, here I must acknowledge the caution offered by Windschitl (2002) that we should not equate *learning* with *activities*, which oversimplifies the potential of constructivist learning theories to inform pedagogies.

The application of constructivist learning theories to pedagogical praxis and pedagogical processes have led to constructivist pedagogies. According to Popkewitz (2016), constructivist pedagogies attempt to encompass the relationship between the practices of knowing and how knowledge is developed from multiple iterations that are guided by learners' past experience and socially negotiated by the learning environment. As such, constructivist pedagogies are strongly connected to theory and practice because the approach takes pedagogies as praxis that is used to both inform practice and refine theories (Branch, 2000). For science education, three is value in synthesising Vygotsky's views of social learning with Piaget's views of cognitive learning to conceptualise a common set of pedagogies because these theories enable a holistic understanding into the dynamic interactions of how science learning is socio-culturally mediated and personally and progressively constructed and reconstructed (Brook, Driver, & Johnston, 1989; Bruner, 1966; Scaife, 2012). In science education, constructivist pedagogies are often popularised as *inquiry-based-science education* (IBSE), which refers to

> at least three distinct categories of activities—what scientists do (e.g., conducting investigations using scientific methods), how students learn (e.g., actively inquiring through thinking and doing into a phenomenon or problem, often mirroring the processes used by scientists), and a pedagogical approach that teachers employ (e.g., designing or using curricula that allow for extended investigations). (Minner, Levy, & Century, 2010, p. 476)

The Learning in Science Project (1980-1989)[5] reported seven key pedagogical characteristics within the constructivist learning approach to science education (Scott, 1987). Figure 2.2 presents Brook et al.'s (1989) modified version of these

[5] I acknowledge that this example is dated, but the theoretical ideas proposed are still useful today.

pedagogical characteristics. However, these characteristics are not unique to teaching science; whatever the discipline, this approach expects a learning environment where individuals are actively involved in their learning process to be able to construct and develop knowledge.

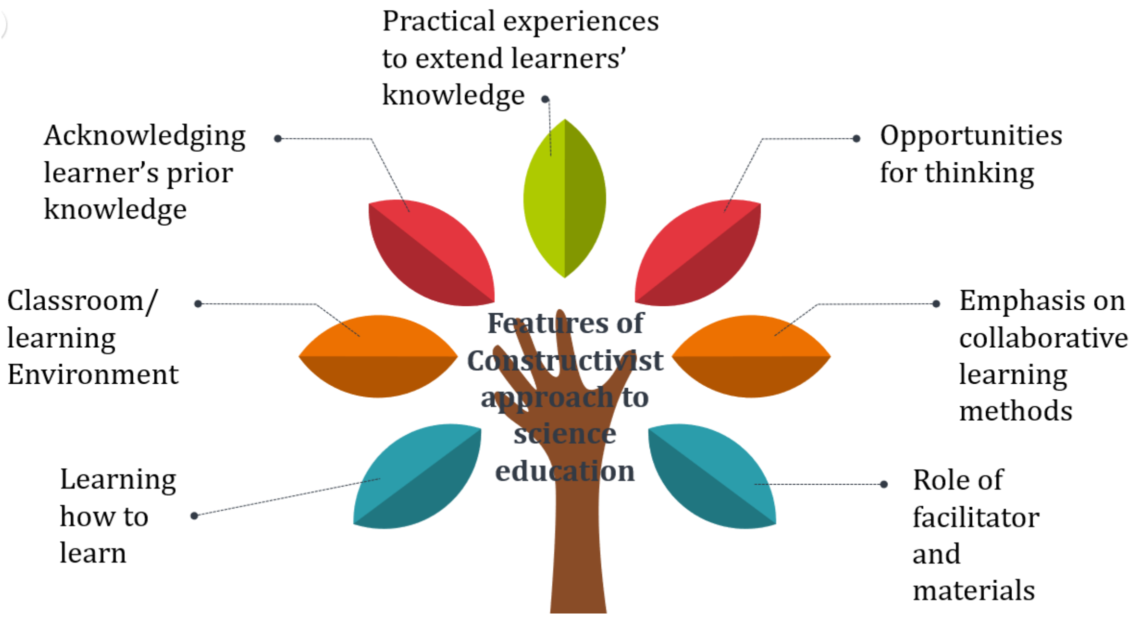

Figure 2.2 Features of constructivist learning theory applied in science education.
Adapted from Brook et al. (1989).

When teachers employ these characteristics to inform their pedagogical praxis, they can appropriately respond to students' diverse learning styles and needs in order to take advantage of individual students' unique starting points while carefully scaffolding learning tasks to facilitate the progressive development of students' understanding of content and associated skills (Darling-Hammond, 1996; Gordon, 2009; Windschitl, 2002). Such an approach also means that teachers have to encourage students to generate new ways of observing phenomena and consider alternative models and approaches to interpret findings, all in a way that probes students' ideas (Brook et al., 1989). Finally, constructivist learning theories provide a sound framework to employ culturally sensitive and contextually contingent science education pedagogies. In Section 2.3, these characteristics are applied to explore SPS pedagogies, but I first briefly identify how the concept of progressive education is applied in this study to differentiate it from the above-mentioned characteristics of constructivist pedagogies.

2.2.1 Progressive education and constructivist learning theories

Progressive education and constructivist learning pedagogies highlight the importance of learners' active roles in constructing learning (Schweisfurth, 2013b; Tikly, 2019). However, Sriprakash (2010) argued that progressive education is a wider and broader developmental view of education that has influenced 'various pedagogic labels, such as child-centred, learner-centred, progressive, humanistic, constructivist, or competence-based education' (p. 1). Tabulawa (2013) and Sriprakash (2012) both concede that under neoliberal international educational policies and discourses, the concept of progressive education has moved away from its liberal origins. Today, the concept of progressive education is often used to describe various forms of Learner Centred Education (LCE; also sometimes referred to as child-centred education or student-centred education); where the term LCE refers to forms and variations of active-learning pedagogic revivals across LMICs (Di Biase, 2015; Tikly, 2019). Despite being broadly informed by Western-centric/Eurocentric ideals of education (Sriprakash, 2012), LCE has become a travelling policy which has been widely popularised by international agencies (Schweisfurth, 2013b, 2013a) and advocated on international platforms as a sustainable education practice (Tikly, 2019) as a universal theory on teaching and learning.

Implications from this simplified, universalist approach to LCE are significant but debilitating for LMICs such as the Maldives because LCE approaches are often used to measure progress in education, demonstrating an implied quality and a nod towards development (Tabulawa, 2003). Thus, in this study, *progressive education* refers to the uncritical transfer of weakly theorised ideas about educational practices and pedagogies (like LCE) from Western contexts while *constructivist pedagogies* refer to the characteristics associated with active learning; I describe this term later in the chapter. Here, constructivist learning theories offer flexible and contingent pedagogies across contexts and different subject areas/disciplines. As such, constructivist progressive pedagogies are used to refer to a combination of these two elements (i.e. LCE with constructivist learning features).

In the next section, I focus further on the pedagogical context to make the argument for teaching and learning of SPS in primary schools.

Section 2.3 Science in primary schooling

In this section, I outline arguments in the literature regarding the importance of science at the primary grades of schooling, especially in the 21st century. I discuss the importance of SPS in primary science education and explore pedagogies for teaching SPS, which are informed by the learning theory discussed in the previous section. This section concludes with a discussion of the role and realities for generalist primary teachers responsible for teaching science, even when it is outside of their specialisation.

2.3.1 Why is science important in primary schooling?

School science is important because certain aspects of scientific knowledge, the pursuit of this knowledge, and skills associated with it are critical for democratic participation in today's societies (Harlen & Léna, 2011; Osborne, 2010; Roberts, 2007; Taber, 2017). Anderson (2007) explained that scientific communities commonly believe that there is a body of 'knowledge and practices that are potentially valuable to members of the general public in their roles as workers, consumers, family members, and citizens' (p. 5). However, such views may promote unjust notions of 'universal science knowledge', which can function as 'new-imperialism practices' that reify neoliberal, capitalist and patriarchal power in science education; whereby this uncritical, 'universal science knowledge' can be both inappropriate and determinantal in certain contexts, especially within the Global South (Asabere-Ameyaw, Dei, & Raheem, 2012; Cobern, 1996; Le Grange, 2007; Tikly, 2004, 2019).

Studies from both Osborne (2010) and Driver, Leach, Millar, and Scott (1996) cited Thomas and Durant's (1987) view on the purposes of contemporary science education, affirming five arguments for school science education, namely: .

- The ***utilitarian/instrumental*** argument: learners benefit from learning science as it applies to daily life;
- The ***economic*** argument: to produce scientists to sustain its economic base and international competitiveness;
- The ***cultural*** argument: science is the shared heritage and body of science as a language, discourse, and product;
- The ***democratic*** argument: to be informed and critical consumers of scientific knowledge; and finally,
- The ***moral*** argument: to appreciate the practice, norms, commitments, and values of science.

As such, Osborne (2010) contended that for a sound science education, all these arguments should be considered simultaneously so that students may

> acquire the confidence and a measure of intellectual independence that will assist them to participate as informed and responsible citizens when faced by the inevitable dilemmas that will be posed by science and technology in the years to come. (p. 67)

With this aim, science education then provides opportunities to decolonise curriculum and shift away from Eurocentric science education epistemologies (Tikly, 2019) together with a belief that science contributes to a common public knowledge, and thus is necessary to be incorporated into primary education; the compulsory schooling years (Osborne & Dillon, 2008). However, Asabere-Ameyaw et al. (2012) cautioned against polarising science education into Western-centric/Eurocentric science and local/indigenous science (Anamuah-Mehsah, 2012; Asabere-Ameyaw et al., 2012; Le Grange, 2007; Mhakure & Otulaja, 2017), indicating that we need to add to the diverse routes by which the aims of science education can be achieved. As Mhakure and Otulaja (2017) noted, though these different forms of science may not harmonise completely, they can complement each other so as to provide a culturally-sensitive science education.

The practices of teaching both types of knowledge base together become critical at primary education level for several reasons. Firstly, learning experiences developed at the primary years impact an individual's capacity and desire for learning science further (Achola & Pillai, 2012; Harlen & Léna, 2011; Reiss, 2015; Ward, 2016a). Similarly, Harlen and Léna (2011) claimed that at the primary schooling stage, learning science satisfies and stimulates learners' curiosity about the surrounding world; by engaging in investigating skills, students begin to recognise the importance of using evidence to support scientific claims. Harlen and Léna (2011) also argued that at the primary school stage, students start to develop attitudes about and interests in science that are uniform across genders; learning science is a positive experience regardless of achievement scores. For these reasons, learning science at the primary schooling age paves the way for promoting school learning experiences that are both positive and meaningful.

Secondly, research findings on how children learn indicate that secondary students' ideas about scientific aspects of the natural world were un-scientific and misinformed, which was attributed to a lack of proper science education during primary schooling years (Harlen & Léna, 2011). Without proper guidance on learning science, students often tend to formulate misconceptions and ill-informed notions about the sciences that can be detrimental to both their future learning and their social lives.

Thus, to overcome such learning barriers, it is vital that the foundations of science are delivered during primary schooling so that primary school students will be provided with science learning opportunities which will in turn help develop scientific ideas (Alexander, 2014, 2016; Harlen & Léna, 2011).

Thirdly, primary science education is important because formal science learning experiences provide the learner with an ability to connect science with other fields of study[6] (Harlen, 2010). Such an understanding is critical today because of the dire need for attention and action for major global issues such as worsening global climate change, the unscientific backlash against vaccinations, or even simply understanding the pros and cons of technological advancements. Science education is thus a critical component of today's formative primary school education.

2.3.2 What science is important in primary schooling? *The case for SPS*

Harlen and Léna, (2011) explained that in order to decide what is appropriate for primary science education, 'we should start by considering the understanding, skills and attitudes we want primary school children to develop' (p. 3). A common and broadly accepted goal for primary science education is for it to improve 'scientific literacy' (Durant, 1994; Laugksch, 2000; Lehr, 2007; Sadler & Zeidler, 2009; UNESCO, 1999). However, the meaning of that term is contested in literature and policy-making (Deboer, 2000; Dillon, 2009; Durant, 1994; Laugksch, 2000; Miller, 1998, 2012; Smith, Loughran, Berry, & Dimitrakopoulos, 2012), though there is consensus that 'scientific literacy' is important and has a place in science education curricula (Archer et al., 2010; Durant, 1994; Duschl, Schweingruber, & Shouse, 2007; Harlen & Elstgeest, 1992; Miller, 2012; Ogunkola, 2013), especially in primary education.

[6]Such as Technology, Engineering and Mathematics (STEM), and/or with Arts (STEAM).

To argue the case of what belongs in a primary education curriculum which seeks to achieve scientific literacy, I use the definition of scientific literacy proposed by Roberts (2007). In his broad conceptualisation of scientific literacy, there are two visions of science education: Vision I and Vision II. Vision I is focussed on learning the *products* (or the scientific concepts) and the associated *processes* of science. Vision II emphasises the learning of science from the context of life situations (Zeyer & Dillon, 2014) and the social contexts in which learning takes place. Roberts (2007) further elaborated that Vision II emphasises that science learning has to be situational and contextual. As such, the products and processes of science cannot be taught in isolation apart from the context of science knowledge and the context of the learners in developing ideas both *of* science and *about* science (Harlen & Léna, 2011). Latour (1987) affirmed that science is not a fixed set of products, but a culturally framed field explored and developed within the context of which it is studied and learnt. Tikly (2019) further argues that science education should embrace the social and spiritual dimensions of cultural and indigenous local knowledge and expertise. For these reasons, I argue that in primary science education, focussing on teaching and applying the skills of science in developing scientific knowledge and the enterprise of science (Gunstone, Corrigan, & Dillon, 2007; Millar, 2010) is not only contextually contingent science education, but democratic and socially just for the students.

A contextually contingent approach is more pressing for lower-middle-income countries (LMIC) such as the Maldives, because our priorities of national development are unique when compared with the rest of the world. For Maldivian future citizens to achieve scientific literacy through science education, the science curriculum cannot be rigid, nor dictated by powerful 'new-imperialist' practices and knowledge (Tikly, 2004, 2019) because such Eurocentric ideas are often not the most relevant for Maldivians and their development. We need to move away from Eurocentric Western science, and towards situational and culturally-sensitive 'retooling' of science education (Asabere-Ameyaw et al., 2012; Tikly, 2019) in LMICs and the Global South.

A contextual approach allows for flexibility and promotes science education as personally and culturally relevant, scientific literacy, significant in primary schools

(Smith et al., 2012). The scientific community believes that scientific knowledge is constantly changing and evolving (Ward, 2016b) and so some primary science content that may not be of use later in their lives and thus is of not worthy of their time. Learning at this age must then focus on developing *skills* which are applicable for the 21st century (Ward, 2016a) rather than asking learners to regurgitate abstract scientific content knowledge.

Thus, I argue that we need to strengthen and refocus our primary science education lens on the *how to* of science to focus our attention onto the way science works. Le Grange (2007) argued that such a focus brings to the forefront the 'doing of science, that is, science [as] a human and social activity that is messy, heterogeneous and situated' (p. 587). Such forms of primary science education enable us to focus on the skills of science, which are known as **SPS***.* The foundation for science learning can be laid by at primary school science through an approach which can 'provide a basic understanding of the processes and practices of science and of the nature of the knowledge that these produce' (Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003, p. 716).

Science process skills (SPS).

Millar (2015) explained that science process skills are those skills that scientists follow and apply when exploring the natural world in order to understand it and develop scientific explanations. These skills are transferable skills and more durable and flexible than content knowledge (Millar, 2010); they involve mental and physical skills (Harlen & Elstgeest, 1992) which are categorised into groups as either basic or integrated (Mutlu & Temiz, 2013; Özgelen, 2012; Padilla, 1990). There is an implied universality to the application of these skills, making them not only important in the teaching of science, but they also function as an ideal basis to integrate science content and form. A list of these skills and definitions are provided in Table 2.1.

Observing, measuring, classifying, inferring, communicating, and predicting are considered basic skills (Ambross, Meiring, & Blignaut, 2014; Aydoğdu, 2015; Padilla, 1990) or general process skills (Wilke & Straits, 2005). These skills should be introduced to students in early school years since successful understanding and application of these skills is crucial for learning science further. These basic or general process skills also they form the basis for integrated SPS (Ango, 2002; Aydoğdu, 2015; Aydoğdu, Tatar, Yildiz, & Buldur, 2012; Harlen, 1999; Harlen & Elstgeest, 1992; Millar, 2010; Padilla, 1990; Roden, 2016; Roden & Ward, 2005; Ward, 2016b).

Integrated SPS, or scientific method skills (Wilke & Straits, 2005) are a complex combination of several basic process skills and so they are a more advanced skill set. These skills include hypothesizing, designing experiments, collecting and analysing data, drawing conclusions, and interpreting evidence (Ambross et al., 2014; Aydoğdu, 2015; Farsakoglu, Sahin, & Karsli, 2012; Padilla, 1990; Yakkar, 2014).

Özgelen (2012) explained that, within a cognitive framework, SPS can also be classified as information processing skills, reasoning skills, inquiry skills, creative thinking skills, and problem-solving skills. When scientists conduct investigations by describing, predicting, explaining, and adapting to phenomena of the natural world, they are using these process skills in tandem with cognitive skills to construct scientific knowledge (Özgelen, 2012). Ediyanto et al. (2018) clarified further that these skills are interconnected and built on foundational basic SPS, where the basic science process skill of observation lays the groundwork to develop the rest of the skills (see Figure 2.3). As previously discussed in this chapter, it is this nature of the SPS which makes teaching and learning of these skills critical in primary science education.

However, in keeping with my comparative sensibilities , it important to note that the skills listed in Table 2.1 can be viewed as favouring a Western epistemic approach. As Tikly (2019) states, these skills are developed based on

> ‘Western-centric’ competitive counterposing of alternative hypotheses and sources of evidence to arrive at robust scientific understanding and an over-reliance on logic-deductive forms of inference. (p. 193)

As such, the use and teaching of these skills need to be adjusted for different educational levels, purposes, and contexts so that ‘diverse approaches to arriving at truth’ (Tikly, 2019 p. 193) can be valued in science education. Such practices highlight the contextual contingencies in learning science and empower both teachers and students in the learning process.

Table 2.1 Science process skills.

Type	Science process skills	Definition (Sources: Ango, 2002; Ediyanto et al., 2018; Padilla, 1990)
Basic skills	**Observation**	Considered the foundational and critical skill on which all other skills depend on. Using our senses (as safe and appropriate) to gather information about an object/event. *Example: describing a pen as red.*
	Classification	Grouping/ordering objects/events into categories based on properties or criteria such as similarities and differences. *Example: Placing all red of the same colour (e.g., red) or the same brand into one group*
	Measurement and use of number	Using either standard or non-standard measures or estimates to describe the dimensions of an object or event. *Example: using a ruler to measure the length of a pen in centimetres.*
	Making Inference	Making an "educated guess" about an object/event based on previously gathered data or information. *Example: Saying that the person who has a red pen could be a teacher.*
	Making Prediction	Stating the outcome of a future event based on a pattern of evidence. *Example: Predicting it will rain in England at a certain period of the year based on meteorological data*
	Communications	Using words or graphic symbols to describe an action, object, or event. *Example: Describing the amount of rainfall in Bristol, England over a year writing or through a graph*
Integrated skills	**Formulating hypotheses**	Stating the expected outcome of an experiment. *Example: The greater the amount of fertiliser added to the soil, the greater the growth of the bean plant*
	Defining Operationally	Stating how to measure a variable in an experiment. *Example: Deciding that plant growth will be measured in centimetres per week.*
	Experimenting	Being able to conduct an experiment, including asking an appropriate question, stating a hypothesis, identifying, and controlling variables, operationally defining those variables, designing a "fair" experiment, conducting the experiment, and interpreting the results of the experiment. *Example: The entire process of conducting the experiment on the effect of fertiliser on the growth of bean plants*

Identifying and controlling variables	Being able to identify variables (as independent, dependent, and controlled) that can affect an experimental outcome and controlling these variables appropriately. *Example: Realising through past experiences that amount of light and water need to be controlled when testing to see how the addition of fertiliser affects the growth of beans.*
Interpreting data	Organizing data and drawing conclusions from it. *Example: Recording data from the experiment on bean plant growth in a data-table and forming a conclusion which relates to the trends in the data to the variables*

The structure of SPS in Figure 2.3 highlights the scope of teaching these skills with above mentioned contextual contingencies, especially at the primary education level, where these skills are best taught as a set of coordinated activities taught as a whole (Shahali, Halim, Treagust, Won, & Chandrasegaran, 2017). Such a coherent structure in teaching these skills is important because, these skills help students to identify and use relevant scientific evidence in problem-solving and decision-making (Harlen, 2000) within real-life contexts (Maral, Oguz-Unver, & Yurumezoglu, 2010) so that students can apply them in whatever employment they later seek since most jobs in this new millennium involve use of these skills (Permanasari & Hamidah, 2013). Harlen and Elstgeest (1992) argued that teaching SPS is important not for 'any supposed value in their right but because of their value in developing concepts' (p. 22-23). Teaching these skills at primary schooling level encourages as the habit of critical and inquisitive thinking (Özgelen, 2012), which is not bound to a culture or geography.

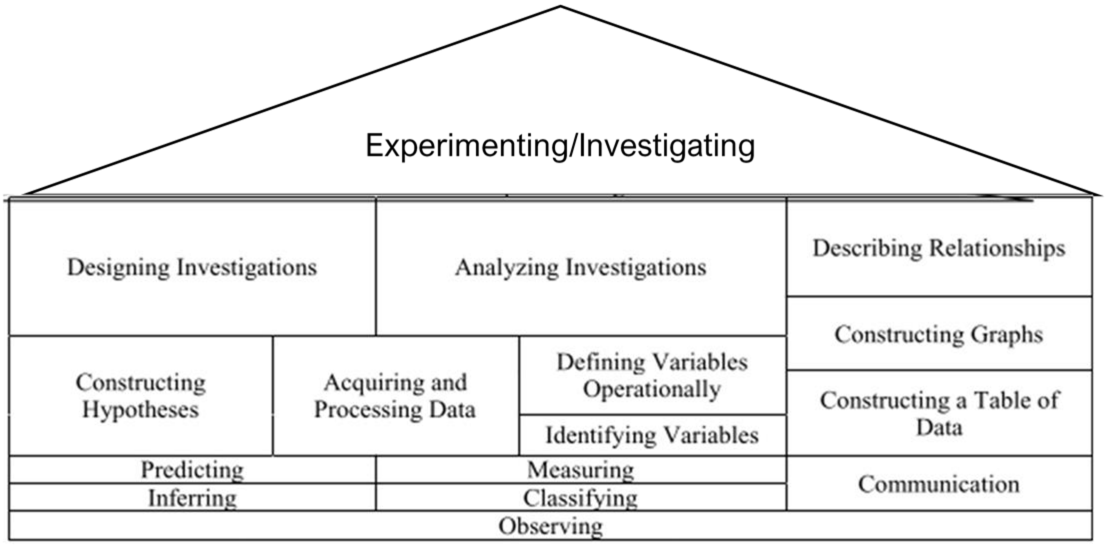

Figure 2.3 SPS connections. Source: Ediyanto et al. (2018).

Despite this wide consensus around the value of emphasising SPS, it is worth considering dissenting voices. The most significant critics include Ault and Dodick (2010), who argued that focussing on skills can effective divorce those skills from the content and thus ignore socio-historical aspects of the nature of science. They further indicated that these skills (especially those of observing and inferencing) have been oversimplified in curricular and classroom pedagogies because human 'belief may distort perception and skew interpretation' (p. 1100) and thus mislead observation skills in classroom teaching. Whilst this is a valid and acceptable argument, my stance here is not in advocating a *single* approach for primary science education, but instead I argue for the significance of teaching SPS within broader science education. As per my ontological positioning (see Chapter 5), I value and accept the existence of different ontologies and epistemologies for primary science education. In response to Ault and Dodick's claim, then, I offer Van Dijk's (2014) defence: Van Dijk argued that the process skills approach is inherently dependent on the content of science because he process skills feeds students' development of the content and vice versa; thus, the two aspects are inherently linked to each other.

In 2.3.3, I connect the conceptualisations of pedagogy (discussed in Section 2.2) and the theoretical basis explained earlier in this section to the SPS that have been discussed in this section to explore various forms of constructivist pedagogies for SPS.

2.3.3 Teaching and learning of primary school science: *Constructivist pedagogies for SPS*

The acquisition of both basic and integrated science process skill is important for successful science learning. As demonstrated earlier in Figure 2.3, basic skills such as observation lay the foundation for learning and applying these skills in science. Students who cannot sufficiently acquire these skills may struggle to connect their conceptual scientific understanding with a procedural understanding of learning science (Duggan & Gott, 1995; Harlen, 1999). Further, as highlighted earlier in this section, constructivist learning theories offer holistic and contextually contingent pedagogies for science teaching that consider both the cognitive and social elements of learning (Appleton & Kindt, 1999).

Constructivist pedagogies for learning SPS provide students with positive learning experiences of teacher-facilitated experimentations and investigations that enable students to construct their own scientific conceptual base (Hattie, 2009; Ramesh & Patel, 2013). Such practices are a critical feature of inquiry-based science education (IBSE), an active-learning approach to science education that emphasises SPS through questioning, experimenting, weighing up evidence, and considering alternative hypotheses (AEMASE, 2014; Johnston, 2009; National Research Council, 2000). The origins of IBSE can be attributed to Dewey's ideas around scientific inquiry, as explained by Johnston (2009):

> Scientific inquiry operates wherever active experimentation takes place. This experimentation can be physical, as in physics and chemistry, but it need not be. Active experimentation can take place at the level of conceptions and ideas. Attempting to understand a scientific-law is scientific-inquiry (or at least, a part of it) when anticipation of consequences takes place. Thought is a central ingredient in scientific inquiry: perhaps the most important ingredient. (p. 34)

Osborne and Dillon (2008) argued that pedagogical practices such as IBSE are valuable for science teaching because such pedagogies provide students opportunities for extended 'hands-on' experimentation without 'stressing on the acquisition of canonical concepts' (p. 9) of science. Further, Wals, Brody, Dillon, and Stevenson (2014) have noted that IBSE approaches rely on teaching investigative skills, allowing for a smooth combination of both the basic and integrated SPS. As such, pedagogies that focus on collective SPS as investigations is referred to as a **science-investigation-based approach (SIBA)** which:

> starts with a question, proceeds then with proposing some hypotheses or arguments to the question, testing such hypotheses or arguments through observation or experiment, drawing some conclusions and at the end communicating such conclusion so as to convince people of the conclusions. (Wan, Wong, & Zhan, 2012, p. 13)

In primary science education, the SIBA 'refer to a specific type of activity where the children test a prediction by changing one variable and measuring the effect, whilst controlling the other variables to ensure what is often called a fair test' (Galton, 2007, p. 15). These investigation-based lessons allow for learning and developing interconnected SPS while highlighting their relation to the key approach to learning science, according to Harlen and Elstgeest (1992).

I adopted the science-investigation-based approach as the SPS pedagogy to explore in this study for five main reasons in addition to those mentioned above. First, the science curriculum in the Maldives specifies the use of investigative approach to teach the SPS (see Chapter 4). As this study is with teachers in the Maldives to support their development of SPS pedagogies, it would seem practical and beneficial for the teachers if their pedagogical praxis is explicitly connected to the curriculum they implement.

Second, SIBA to teach science and SPS is an economical way of providing support for both conceptual and procedural understanding (Cavalcante, Newton, & Newton, 1996; Trna et al., 2012); attention paid to economic factors in essential for a Maldivian primary science classroom due to the limited classroom time, space, and resources.

Third, a framework of science-investigation helps to structure the science lessons so that they integrate SPS with the science content while developing the lesson around issues and problems that primary students can concretely explore (Driver, 1994; Harlen & Elstgeest, 1992; Harlen & Léna, 2011; Smith et al., 2012). In particular, Gott and Duggan (1995) argued that through science investigations, students learn to connect the content of science (conceptual understanding) with the process of science (procedural understanding), because the investigation framework enables students to apply the content of science when collecting, synthesising, and evaluating scientific knowledge and data. Further, the Cambridge Primary Review in England (2010) reported group-based investigation in science lessons promote students' achievement in primary schools, especially at Key Stage 2 (Alexander, Doddington, Gray, Hargeaves, & Kershner, 2010). Galton (2007) also agreed that teaching science through such an investigation-based approach is powerful because it enables the combination of a broad set of process skills into one single classroom learning activity, which challenges students' ideas and thinking.

Fourthly, the science-investigation-based approach facilitates exploratory talk in the classroom (Barnes, 2008), because students apply these skills to connect the content of science to the skills as they engage in dialogue facilitated by the teacher and peers (Alexander, 2017, 2018). According to Alexander (2018), such exploratory talk is similar to Vygotsky's 'collaborative thinking as a route to acculturation as well as learning' (p. 3). Thus, while students develop the necessary vocabulary for learning and exploring science as they engage in SPS, the content of science and skills of science develop in tandem (Cavalcante et al., 1996; Duggan & Gott, 1995).

Finally, SIBA practices allow students to critically question claims made by others, including both their peers and the broader scientific community. Such practices require guidance from the teacher so that the learning experience can be scientifically appropriate, make use of the cultural tools and conventions of the science community available, and be accessible to students (Driver, Asoko, Leach, Mortimer, & Philip, 1994). Such hands-on learning experiences are critical for primary students to retain their science learning, especially when they are experiencing an overcrowded science curriculum (Cavalcante et al., 1996).

The teacher's role in employing such investigation-based pedagogies is to help students instil investigation-based scientific explorations as systematic, organised, and meaningful to students: they are constructing meaning through their own activities, discussion, reflection, and sharing of ideas with their peers (Hattie, 2009; Roden & Ward, 2005; von Glasersfeld, 1989). For this to happen, it is paramount that teachers should have sufficient knowledge and understanding of SPS (Harlen, 1999; Özgelen, 2012). Along these lines, Driver (1994) reiterated that especially in the investigation based approach, it is critical that teachers can provide the necessary guidance and facilitation for students' exploration of the scientific content and principles because without such guidance, students' alternative concepts or misconceptions of scientific ideas may pose challenges and difficulties to learning science. Thus, teachers' knowledge of science, SPS, and the associated pedagogies are paramount in facilitating students' development of science. This matter is further problematised in section 2.3.4.

The pedagogical approaches for SPS that have been discussed in this chapter may suggest a universalist approach to science education that ignores the contextual contingency of the learning process itself. My argument is not for universal science education pedagogies, nor reducing science education to an alternatives 'between skill-based and process-based pedagogy' (O'Loughlin, 1992, p. 808). Further, it is also not about arguing that all aspects of primary science can be taught by these pedagogical approaches (Galton, 2007). I argue that the suggested science-investigation-based approach is informed by constructivist learning theories and so this approach allows us to consider how individual students construct their own learning of science in a way that is flexible and contingent upon the context of classroom, the school education system (O'Loughlin, 1992), and the socio-cultural and historical mileu of the country and its indigenious/local epistomologies (Asabere-Ameyaw et al., 2012; Mhakure & Otulaja, 2017; Tikly, 2019). The science-investigation-based approach to pedagogy offers this culturally sensitive flexibility (Mhakure & Otulaja, 2017) that would allow teachers to freely move away from recipe-style foreign approaches to teaching science (Cavalcante et al., 1996). However, such flexibility is restricted and limited when generalist teachers are teaching science outside their specialism, as I present in 2.3.4.

2.3.4 The generalist primary school science teacher: *Issues and opportunities*

In the previous sections, I have argued that science is critical in primary schooling because it enables opportunities for students to learn critical knowledge and gain transferable skills. Further, I have also argued that in primary science, the development of SPS is important because these skills not only provide students with the tools to continue to further their scientific knowledge, but they also provide contextually contingent life-skills and knowledge. Following this argument, I have discussed that **science-investigation-based approach (SIBA)**, as a constructivist pedagogy, offers a flexible and relevant pedagogical approach to teach SPS. This approach integrates SPS together with science content and also allows enough flexibility to modify and differentiate the learning experiences in order to adapt to the classroom milieu and dynamics, providing teachers with the necessary autonomy in pedagogy-related classroom decision-making. The assumption here is that the teacher making those decisions, is specialised in science.

In many countries across the world, primary teachers considered as class teachers are generalists (Ardzejewska, Mcmaugh, & Coutts, 2010; Elliott, 1985; Fitzgerald & Smith, 2016). According to Alexander (2011), across the world, this practice has been inherited from nineteenth century elementary schooling systems. A generalist teacher is required to teach the core-curricular subjects of literacy and numeracy along with specialised subjects such as history, geography, arts, and science. Excessive and often unrealistic curricular demands placed on generalist teachers in primary grades[7]; despite the problematic nature of this arrangement, it remains common practice in many countries (Reiss, 2015), including the Maldives, and one that is unlikely to change in the near future (Alexander, 2011).

According to Elliot (1985), there are three basic reasons for the primary generalist teacher arrangement. Firstly, primary-aged children need a key point of contact at their school. For these young students, having one class teacher delivering most of their subjects provides the students with some consistency and stability to their social interactions, which from a cognitive development perspective is an ideal arrangement for these students (Alexander, 2016; Elliott, 1985; Pezaro, 2017; Reiss,

[7] http://www.educationengland.org.uk/documents/threewisemen/threewisemen.html, and Alexander (2010, 2011, 2016).

2015). This embodies the sentiment of 'we teach children, not subjects' (Alexander, 2016 p. 5). Secondly, this arrangement allows for the curricular integration and thematic delivery of the primary school curriculum, providing a seamless learning experience for the students. According to some researchers, this arrangement is ideal for science teaching because this structure promotes a concerted effort for science instruction that supports the development of scientific literacy at the primary years (National Research Council, 2007). A third reason is that hiring generalist teachers is financially preferable to hiring multiple subject-specialist teachers for each grade level (Alexander, 2014). Thus, in most LMIC (including the Maldives) where there are strong financial constraints on the education system (see Chapter 4), pre-service primary teachers are best 'trained' as generalist teachers with a spectrum of professional skills (and content knowledge) to teach the breadth of all basic subject areas in the primary school curriculum[8].

However, the practical challenges to realising the above ideals reduces them to a theoretical and romantic ideal and thus has led to widespread critique of generalist teachers as not ideal to teach specialised subjects such as science in primary grades (Ardzejewska et al., 2010; Goodnough, 2008; Steele, Brew, Rees, & Ibrahim-Khan, 2013). From these critiques, I highlight three arguments relevant to this research, with a particular focus from the Maldivian context (to be elaborated later in Chapter 4). Firstly, at pre-service, the preparation of primary school teachers in specialised subjects such as science is woefully inadequate (Keil, Haney, & Zoffel, 2009). This situation is exacerbated by the fact that most of these pre-service teachers do not have A-Levels in any science subject (Turford & Turner, 2018).

Secondly, this matter is further intensified by an overcrowded primary curriculum which requires teachers' expertise and specialised knowledge in all the subjects, together with the necessary knowledge to integrate subjects as cross-curricular

[8] In the Maldives, as discussed in Chapter 4, subjects such as Divehi, Islam and *Qur'an* are taught by specialist teachers.

themes (Alexander, 2011; Ardzejewska et al., 2010). However, some of the primary school subjects have unique epistemologies requiring specific pedagogies. For example, Ango (2002) indicated that a teacher of science ought to master the nature of SPS and its associated pedagogies to optimise students' learning of science. To teach SPS using science-investigation-based approach, teachers need expertise not only in science content but also in how to structure and facilitate science investigations to optimise students' learning of both the skills and the content of science (Osman, 2012). Generalist primary teachers often lack such specific science content knowledge and the unique pedagogies, the attitudes, and the self-efficacy to teach science confidently (Childs & McNicholl, 2007; Turford & Turner, 2018). When generalist teachers are required to teach science with a limited pedagogical palette (Barrett, 2007; Schweisfurth, 2011), the learning they can provide to their students is divorced from the nature of learning science because 'it is difficult to evoke and develop another person's latent talent if your own understanding of the field in question is limited', unless you are a 'renaissance super-teacher' (Alexander, 2016 p. 5). Alas, such super-teachers are not the norm.

Thirdly, primary teachers have become a 'Jack of all trades'[9], and often put enormous pressure on themselves to simply learn the science content they needed to teach, without even considering the amount of time needed to acquire subject-specific pedagogies for teaching the content of science (McNicholl, Childs, & Burn, 2013). Consequently, generalist primary teachers tend to avoid teaching specialised subjects such as science (Alexander et al., 2010; Childs & McNicholl, 2007; Fitzgerald & Smith, 2016; Goodnough, 2008; N. Halai, 2012; Steele et al., 2013). However, this solution ignores the critical role of science education, as argued earlier in this chapter.

[9] From https://www.bbc.co.uk/news/10522188

With all these issues and challenges, I offer a few solutions. One is to have specialised science teachers at primary education level and in particular for upper primary years (Ardzejewska et al., 2010): in many countries across the world, private schools have subject-specialised teachers at the primary level, so public school systems should make this a priority. However, as noted above, with financial constraints, few public-school systems are inclined to invest in specialist teachers and schools themselves may not have the option to do so. Another solution can then be to have a mix of generalist, semi-specialist, and specialist teachers in science (Alexander, 2004, 2011). This solution then can provide both public and private schools with the necessary staffing flexibility to support delivery of the essence of the curriculum to the students. However, Alexander (2011) observed that in England, the suggestion to have a full spectrum of teachers was unpopular because the generalist teachers saw specialist teachers as a threat and secondary school heads resisted this change, believing that training primary school specialist teachers would reduce funding to train specialist teachers for the secondary level.

Alternative views and advantages to the generalist teacher arrangement have also been suggested. Reiss (2015) and Pezaro, (2017) argued that primary teachers, with their breadth of knowledge and their placement in schools which broadly lack fancy science laboratories, are actually at an advantage because their existing knowledge enables them to connect science learning across many subject areas. Further, Reiss (2015) explained that when no specialised science laboratories exist, primary teachers can take their science learning outside the classroom to locations such as the home, parks, museums, and natural reserves. With the breadth of subject areas and the opportunity to connect science to various settings, primary teachers can make teaching and learning of science more meaningful and engaging to their students.

Thus, Pezaro (2017) wrote that we need to move away from seeing primary teachers in a deficit model. She argues for primary schools to involve teachers and provide and enhance teachers' professional capital through high quality teacher professional development and learning activities and opportunities; this investment will enhance primary teachers' pedagogies, especially for science teaching. Turford and

Turner (2018) expanded on this argument by noting that in many countries, primary education experiences a fast changing, rapid flow of changes to policy, curriculum, assessment and school-based initiatives, necessitating that teachers engage in ongoing professional learning activities. Finally, Sorensen, Twidle, and Childs (2014) argued that such teacher professional learning (TPL) is critical for generalist primary teachers when teaching science outside their specialism, so the development of their unique 'signature pedagogies' (Shulman, 2005) for science can be enhanced and promoted. For generalist teachers, then, professional development and learning are opportunities where subject-specific professional learning is meaningful and useful.

Conclusion

In the review of literature in this chapter, generalist primary teachers' difficulties associated with teaching science process skills were emphasised. I first differentiated between *pedagogies as* ***practice*** from *pedagogy as* ***praxis*** that is processual. Nind et al.'s (2016) dimensions of pedagogies were presented as a useful conceptual framework to explore *pedagogies as* ***praxis*** and to understand how each of the dimensions in this model interact with and have an impact on the contextual contingencies of learning science. Further, constructivist learning theory was used to frame SPS pedagogies, because this theory enables us to consider the contextually-contingent nature of learning.

The review of literature on primary science education reveals that teaching SPS is critical not only for purposes of scientific literacy but also to promote transferable skills such as decision-making and problem-solving. Teaching SPS enables culturally-sensitive teaching of science that moves it away from Western-centric science. In this study, SPS are viewed as transferable skills and involve both thinking and physical aspects that are also unique to the inquiry of science. Examples of these skills are observing, measuring, hypothesising, and experimenting. From the literature review on pedagogies, I argued that constructivist pedagogies enable socially-mediated learning as well as individual cognitive learning processes. Thus, SPS pedagogies derived from constructivist pedagogies benefit both teachers' and students' learning of science. As such, **science-investigation-based approach (SIBA)** was presented as a valuable constructivist SPS pedagogy because it enables contextually-contingent learning of SPS. Finally, despite the value of such pedagogies in teaching SPS, this literature review has also highlighted that when primary teachers are generalists, teaching science can be taxing because their non-specialist educational background, together with various systemic challenges, limit their pedagogical palette.

In the next chapter I review the literature on teacher professional learning as one way to enhance teachers' pedagogical palettes.

Chapter 3. Teacher Professional Learning

> We have always confronted philosophical questions about how knowledge influences behaviour, of course, but the question is further complicated in the case of teaching because teachers have already developed systems of practice that they believe optimally resolve the various challenges they face.
>
> (Kennedy, 2016, p. 955)

Introduction

The previous chapter highlighted that generalist primary teachers' limited grasp on pedagogies poses difficulties for them to teach science process skills (SPS). The purpose of this chapter is to review the literature on teacher professional learning (TPL) to explore how learning mechanisms can enhance generalist primary teachers' pedagogical palette.

In Section 3.1, I first conceptualise teacher professional development as TPL and explore elements of TPL to arrive at a set of features that can be used to inform the development of a contextually-contingent TPL inquiry. In Section 3.2, I review the literature on primary teachers' professional learning for teaching science in order to understand issues with current practices. Next, in Section 3.3, I present social learning theory as the chosen theoretical lens to explore and understand teachers' professional learning and apply this theory to identify relevant features of a professional learning engagement which considers learning as individual, collective, contextual, and processual. Finally, in Section 3.4 I present the broad theoretical framing of this study wherein **social constructivist learning theory** is applied to explore teachers' professional learning experiences alongside their evolving pedagogical praxis for SPS.

Section 3.1 Conceptualising teacher professional learning

In this section, I present a conceptualisation of the term ‘professional learning’ within a broader understanding of teacher professionalism. Teacher professionalism has varying meanings and is itself ‘a discourse that remains associated and imbued with positivity’ (Moore & Clarke, 2016, p. 671). It is an integral part of teacher learning and vice versa (Day & Sachs, 2004; Demirkasimoğlu, 2010; Evans, 2011, 2015; Groundwater-Smith & Mockler, 2009; Hargreaves, 2000; Kennedy, 2015; King, 2011; Mitchell, 2013; Mockler, 2005). Teacher professionalism considers a teacher’s ideas, values and beliefs, practices, and discourses which encompass the plurality of both individual perspectives of autonomy and agency as well as the externally imposed expectations which dictate the profession (Evans, 2014; Mitchell, 2013). In this study, I apply Day and Sachs’ (2004) categorisation of teacher professionalism, namely **managerial professionalism** and **democratic professionalism** to define TPL. Although their intention in this typology is not to polarise views of teacher professionalism, I adopt this classification for the purpose of differentiating teacher professional development (PD) from TPL.

Managerial teacher professionalism is driven and legitimised by economic agendas of global competitions and political ends (and gains), promoting a discourse of performativity, control, and authoritative compliance to externally-set standards and regulations (Borko, 2004; Day & Sachs, 2004; Kennedy, 2005; Mockler, 2013; Sachs, 2016). While this form of professionalism is morally and unethically demeaning to teachers themselves (Borko, 2004), it is propagated by hegemonic powerful global education discourses that promote a ‘hyper-narrative’ of global homogenic standards, such as those mandated through popular international assessments[10] and

[10] For example, PISA and TALIS.

associated policies[11] (Kennedy, 2015). These ideals of teacher professionalism subscribe to transmissive models of teacher PD that view teachers from a deficit point of view and offer one-shot-workshops and technical 'trainings' (Kennedy, 2005, 2014) with the sole purpose of improving students' achievement while essentially ignoring the active role of teachers in the process (Boylan, Coldwell, Maxwell, & Jordan, 2018). Teachers are assumed to be technicians and passive transmitters of curricular knowledge (Kennedy, 2014); as unquestioning operatives (Alexander, 2011), that obediently comply with the government policies that exploit them (Kennedy, 2015). Managerially-focussed PD thus ignores quality over quantity and substance over measurable outcomes. Consequently, the outcomes of PDs are fragmented, intellectually superficial, and irrelevant for teachers' individual learning needs (Bishop & Denley, 2007; Borko, 2004; Duncombe & Armour, 2004). PD then becomes 'spray-on' (Mockler, 2005) or 'hit-and-run' (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). In Chapter 4, I argue that as with other contexts across the globe, managerial professionalism has been influential in determining teacher PD in the Maldives (Naseer, 2018; Saeed, 2008; Saeed & Moreira, 2010).

Under such conceptualisations of teacher PD, we cannot account for what I argue is the core, fundamental objective of PD itself: namely, *teachers' professional learning*. Timperley (2011) separated teacher professional development from TPL since 'professional learning requires teachers to be seriously engaged in their learning whereas professional development is often seen as merely participation' (p. 5). Bishon and Denley (2007) also noted that, with reference to science teachers, a PD approach for teacher professionalism cannot bring about changes to both teachers' and students' learning, but a professional learning view enables a holistic account in addressing teachers' professional needs. Thus, I argue that teachers need

[11] For example, OECD, World Bank, European Union

professional learning, not professional development: this view shifts teacher professionalism from a managerial conceptualisation to a democratic form.

Day and Sachs (2004) outlined democratic teacher professionalism, which promotes collegiality and collaborative, cooperative actions between teachers and other stakeholders. Such an approach to professionalism promotes an expanded social and collegial role of teachers as mentees, that is part of resource-networks constructing a shared sense of professionalism to respond to the intense and often capricious external demands made on their profession (A. Hargreaves, 2000). Additionally, such an approach allows us to see TPL as something beyond only a means to improve students' learning outcomes (Evans, 2014); a democratic approach moves teacher professionalism beyond reform movements and the culture of performativity and standardisation (Day & Sachs, 2004; Sachs, 2016). Such an approach to teacher professionalism promotes quality professional learning through deeper and more meaningful engagement with teacher praxis. Professional learning practices like these set precedence for an active-learning culture amongst teachers and students alike (Barrett & Avalos, 2011; Hattie, 2009), promoting continuity in learning processes (Timperley, 2011). In this study, professional learning thus refers to the individual and social actions that are mediated by teachers' contexts (Evans, 2014; Fraser, Kennedy, Reid, & McKinney, 2007; Opfer, 2016) in shaping teachers' pedagogical praxis.

It is important to point out that concepts of TPL and PD are not mutually exclusive. As Fullan and Hargreaves (2016) articulated, these two concepts interweave and overlap with each other in different ways. This overlap is of value in this research because I hold that PD is effective when it embraces a professional learning element, with emphasis on the *learning* rather than the *development* constructed (Stewart, 2014). I elaborate on these elements below.

3.1.1 Elements of teacher professional learning

Teacher's professional learning is a complex, multifaceted phenomenon that can be attributed to a wide range of activities, engagements, and situations (Borko, 2004; Mitchell, 2013). There are different views on and approaches to TPL, but most literature tends to present a bifurcated view of TPL, seen in examples such as informal learning vs formal learning (Borko, 2004; Desimone, 2009; Eraut, 2000, 2011); planned vs unplanned (Bishop & Denley, 2007; Eraut & Hirsh, 2007; Postholm, 2012); individual vs collective (Clarke & Hollingsworth, 2002; Eraut & Hirsh, 2007); or product vs process (Desimone, 2009). While these polarisations maybe useful in order to consider alternative practices, they can distract from the key focus of *teacher learning*. Thus, if we are to understand how professional learning occurs amongst and within teachers, we need to use a heuristic of a continuum rather than a binary. As such, this research has explored TPL from and through its *multifacetedness*, paying attention to how the previously discussed elements all coalesce from a broader spectrum of forms of professional learning to help understand the intricacies, nuances, and micro-processes of primary teachers' professional learning experiences.

Formal activities of TPL include traditional school-based professional development or training workshops or courses (Borko, 2004; Darling-Hammond et al., 2017; Desimone, 2009). As argued earlier, these types of activities emulate transmissive models of teacher development that embody managerial teacher professionalism. These types of activities are prevalent in schools across the world, but teachers across contexts have reported that formal professional learning activities has the least amount of impact on their praxis because these activities do little to support their teaching (Duncombe & Armour, 2004; Keay, Carse, & Jess, 2019; McElearney, Murphy, & Radcliffe, 2018). Conversely, informal activities often tend to be unplanned or organic, promoting practices of democratic teacher professionalism. According to Eraut and Hirsh (2007), informal learning activities accounted for the majority of teacher learning. Such activities for professional learning can range from (reflective) conversations with another or one's self (Osborne et al., 2019) to sharing an experience such as through peer-coaching (Darling-Hammond et al., 2017; Desimone & Pak, 2017; Yee, 2016), co-teaching, or even blogging (Ciampa & Gallagher, 2015). Postholm (2012) argued that professional learning occurs every time a lesson is taught, an assessment is administered, a curriculum is reviewed, or a professional journal or magazine is read. The learning impact of such activities occurs when they create substantive engagement with teachers' daily classroom practices (Desimone, 2009; Eraut, 2004; Retallick, Groundwater-Smith, & Clancy, 2011).

For this reason, we need to move away from Eraut's (2004) concept of TPL as implicit and towards Mitchell's (2013) notion that professional learning needs to be more explicit and conscious, with active engagement and focussed reflections.

The elements of TPL becomes further complex when we consider teachers' professional learning as a process of both **active individual construction** and the **collective co-construction** of norms and practices within the community (Desimone, 2009). Further, there also exists the need for TPL to be relevant, of interest and motivating for the teachers, both individually and collectively. Grangeat and Kapelari (2015) expanded on this by arguing that teacher learning is about the transformation of teacher professional knowledge in a continuous and evolving process; it is dependent on the social context, resources, and repertoire of practices available in the community. Such a contextually-contingent approach to TPL is possible when we consider TPL as combining all these multiple elements to understand how they can work together to shape teacher professional. As such, professional learning is both an individual learning process as well as a collective social learning process where the meaning within teacher praxis is (re)discovered. Consequently, TPL is dynamic, continuous, social, cognitive, and inherently embedded in teachers' professional lives (Barron & Darling-Hammond, 2010; Desimone, 2009; Eraut, 2004).

Another critical aspect of the nature of professional learning explored in this research is the way in which professional learning is connected to teachers' work: their pedagogical practices. Stoll, Harris, and Handscomb (2012) argued that pedagogical exploration is critical to professional learning and vice versa. Further, professional learning opportunities are the means by which teachers can learn the potential of various pedagogical elements in their teaching and thus enhance their capacity in teaching subjects such primary science (Bishop & Denley, 2007; Gomez Zaccarelli, Schindler, Borko, & Osborne, 2018). Teacher's pedagogical praxis and their professional learning are bound together as means for developing intellectual and professional capacities of both teachers and students (Alexander, 2011, 2014) through establishing an professional evidence-base for teachers' practice (Bishop & Denley, 2007; Stoll et al., 2012). Handscomb (2019) articulated that, through such forms of professional learning, 'learning is seen as the *raison d'être* of the whole school' (p. 40

This study explores professional learning through teachers' pedagogical praxis for SPS.

3.1.2 Features of teacher professional learning activities

When designing a TPL engagement that promotes democratic teacher professionalism, we have to consider the above discussed elements of professional learning. Such a learning engagement would then comprise multiple learning activities (Cordingley et al., 2003; Darling-Hammond et al., 2017; Kennedy, 2005; Patton & Parker, 2017) which take place over a prolonged period of time (Darling-Hammond et al., 2017; Porritt & Earley, 2010; Smith, 2014). This engagement occurs in the context where teaching occurs (Luguetti, Aranda, Nuñez Enriquez, & Oliver, 2019) and allows flexibility in the nature of learning. Further, there should be collegial social interactions within the community of learners and individual meaning-making processes whereby teachers can constructively examine, reflect and transform what happens inside their classrooms (Cordingley et al., 2003; Darling-Hammond et al., 2017; Luguetti et al., 2019; Patton & Parker, 2017; Smith, 2014; Stewart, 2014). Table 3.1 annotates some of the key features[12] of professional learning engagements that are relevant to this study.

[12] Sources for this compilation include Cloonan (2018); Cordingley et al. (2003); Darling-Hammond et al. (2017); Desimone and Garet (2015); Dillon and Teamy (2002); Kennedy (2005); Little (1982); Loucks-Horsley et al. (2010); Patton and Parker (2017); Patton, Parker, and Tannehill (2015); Porritt ans Earley (2010); Smith (2014); Stewart (2014); Stoll et al. (2012); and van Driel, Beijaard, and Verloop (2001).

Table 3.1 Features of professional learning activities.

It is **collaborative**, collegial, and shared meaningful learning based on mutual respect and collective participation.
It **enhances teachers' pedagogical skills** and content knowledge that impacts both students' learning and teachers' learning.
It is **ongoing** and **sustained** over a prolonged duration.
It is developed **reflecting on existing practice** to establish relevance and **connect** classroom practice with the professional learning.
It acknowledges **learning as a social enterprise**, focussing on active learning.
It is facilitated with care, fostering a feeling of self-growth, **ownership of the learning innovation** and the associated growth between individual and collective.
It uses coaching/mentoring, peer-support, and external support to create **multiple opportunities** for teacher engagement in learning and practice.
It uses **action research** as a key tool that provides opportunities for collaborative experimentation, evidence-based for learning, reflection, and feedback.

In this section, I have argued that from a teacher professionalism perspective, managerial approaches promote the specific construct of static teacher PD, while a democratic professionalism perspective enables us to consider a broad, holistic view of TPL. Using a professional learning lens on the evolution of teacher' pedagogical praxis allows us to consider the individual, collective, and contextual contingencies found within the learning process. Further, in exploring the nature of this form of TPL, we need to shift our views of professional learning away from polarising binaries (such as informal vs formal, planned vs unplanned, individual vs collective, and product vs process) in order to consider how combinations of these elements shape TPL. This approach to learning is significant for subject-specific professional learning. In the next section I explore primary teachers' professional learning practices in teaching science, to better understand why they require subject-specific professional learning of the nature that has been discussed in this section.

Section 3.2 Teacher professional learning in primary school science

In this research, I examine generalist primary teachers' professional learning around the application of constructivist pedagogies for science, specifically with the chosen science-investigation-based-approach. As the scope of this study is on SPS pedagogies, I will focus this discussion on generalist primary teachers' professional learning experiences with regard to teaching science. The purpose of such an exploration is to understand these practices and experiences to argue for the provision of subject-specific, pedagogy-focussed TPL for generalist teachers.

As has been argued in Chapter 2, primary schooling is complex and challenging (Turford & Turner, 2018): primary teachers maneuverer constant policy changes that require them to respond positively and professionally, while navigating the teaching of an overcrowded curriculum. Under such circumstances, primary teachers seek professional learning opportunities to support their understanding and pedagogical praxis to complement the ever-changing landscape of primary school education.

Professional learning is critical for teaching science for two main reasons. Firstly, initial teacher qualifications do not adequately prepare primary teachers to teach science and SPS (Keil et al., 2009). Further, as Turford and Turner (2018) observed in the context of England, most primary teachers do not have a degree or an A-Level qualification in science; a similar situation exists in the Maldives. As a consequence, these teachers have lower confidence in teaching science when compared with their science-educated counterparts. Secondly, teachers' views of nature and processes of science impacts heavily on how they represent primary science to the students (Shapiro & Last, 2002). When primary teachers are teaching science without embracing the nature of science as a human endeavour and as a process, they tend to view and teach science as a product of 'what should students know and do' (p. 8). Duschl, (2000) further affirmed that teaching primary school science without this epistemological basis results in students' poor understanding and inability to appreciate science and its processes, defeating the endeavour of school science. The unique situation of the Maldives, which reflects the challenges expressed in this paragraph, will be discussed at length in Chapter 4.

Within the current environment of ongoing curricular change in the Maldives, generalist primary teachers are at a further disadvantage because they do not have a strong content base that would allow them to confidently interpret the new curriculum documents. The information provided in the curriculum may seem simple, but it tends to create a level of vagueness about the science content and the pedagogies to be employed (Barron & Darling-Hammond, 2010). Further, this situation becomes worse when the TPL opportunities provided by schools focus only on literacy and numeracy as legitimate proxies for a well-balanced curriculum plan and implementation (Alexander, 2011); this practice grossly ignores professional learning support to implement the science curriculum. Consequently, as Allen and Sims (2017) pointed out, under such circumstances it comes as no surprise that primary teachers often exit the profession, frustrated and disenfranchised.

Turford and Turner (2018) argued that opportunities for developing and 'learning science is an entitlement for all primary teachers and should be part of all teachers' professional lives and all schools' strategic plans' (p. 216). Learning how to teach science concepts is not only important professional learning for teachers (Keil et al., 2009; Zeegers, Paige, Lloyd, & Roetman, 2012), but it also provides a mechanism for teachers to expand their science content knowledge so that their understanding of science and its processes can be enhanced throughout their career (Bishop & Denley, 2007). McNicholl et al. (2013) observed that for primary teachers working outside their specialism, professional learning and collective peer support is valuable and makes a difference in their pedagogical praxis.

Despite this importance placed on primary school teachers' needs and the important place for professional learning opportunities that support their science pedagogies, research shows that in countries such as USA, UK, New Zealand, and

Australia[13], science is rarely a focus of TPL and development activities (Overton, 2018; Timperley, Wilson, Barrar, & Fung, 2007; Turford & Turner, 2018). In the context of Tanzania, where a competency-based-curriculum (CBC) was implemented in the mid-2000s, Mohamed and Karuku (2017), argued for the importance of teacher professional development and learning opportunities as a significant way to develop science teaching, familiarise teachers with available teaching resources, and facilitate a space for teachers to share experiences. In the Maldives, primary teachers are in a similar situation (see Chapter 4).

Research conducted in various countries can provide direction about how generalist primary teachers' pedagogies for teaching science and its associated skills can have a positive impact on teachers' classroom practice and contribute to their professional learning. Timperley et al.'s (2007) meta-analysis of research from the UK and USA on generalist teachers' professional learning indicates that a significant impact comes when professional learning is focussed on collegial and school leadership support and provides multiple opportunities for participants to learn and to practise teaching science. From an Irish perspective, Smith's (2014) study featured generalist primary teachers embarking on a two-year project of professional development programme focussed on supporting the teaching of science; the results indicated an increase in teachers' confidence in teaching science, which was associated with a better understanding of science and their associated pedagogies. Smith also pointed out that his participants reported that following their professional learning experiences, they do not avoid teaching science and felt confident to make their classroom more explorative and hands-on spaces where students could do open investigations. Similarly, in the Philippines, Gutierez's (2016) study with generalist primary teachers engaged in science teaching professional learning activities found that

[13] These countries are referred to here because for various education policy formulations in the Maldives, we refer to their resources, practices and examples, the uncritical borrowing of these ideas is questionable, however.

teachers who lacked specialised knowledge improved through collegiality and collaborations set up through their professional learning activities. Gutierez also reported that professional learning is meaningful when it is continuously emphasised and made directly applicable to their science teaching. From a Thai perspective, Kijkuakul (2019) showed that generalist primary teachers engaged in science professional learning made a positive difference in their science teaching pedagogies; the author further argued that profession learning opportunities are sound mechanisms for pedagogy-based support.

It is clear from research findings such as these that generalist primary teachers' value, benefit from, and prefer their professional learning opportunities to be based on teaching approaches of science, and such focussed professional learning opportunities have greater impact for teachers' pedagogical approaches, confidence, and overall teacher professionalism. All of these studies used constructivist learning approaches to first orient the teachers to the required science content knowledge and then explored teachers' application of those constructivist pedagogies in their classrooms. As discussed in Chapter 2, constructivist pedagogies for SPS is significant for primary science education.

The purpose of this section was to argue on the importance of providing subject-specific TPL for generalist teachers. Here, I have presented the suppressive conditions and demands generalist primary teachers face, with little or no support to teach science outside their specialism. As such, generalist teachers have a limited pedagogical palette with few opportunities to expand or evolve their individual teacher learning needs or access collective collegial support. The literature further supports my choice to employ a science-specific pedagogical inquiry as a mechanism for generalist primary teachers' professional learning.

In the next section, I move on to discuss the theoretical application of how professional learning was explored in this study to develop the model utilised as a structural lens to understand the associated micro-processes.

Section 3.3 Theoretical framing of teacher professional learning

In Chapter 2, I discussed that for science pedagogies, and in particular for teaching science process skills, constructivist learning theory is valuable for students' science education. In this section, I apply social learning theory to TPL. The chapter ends by merging these two theories (constructivist learning theory and social learning theory) under broader social constructivist learning theories.

Inquiries into TPL have much to offer if explored from a social perspective. This study applies a social perspective on TPL, in particular, following the social learning theories as proposed by Wenger (1998). Wenger's theory was developed based on learning theories proposed by academics such as Bandura (1964) and Vygotsky (1978). Wenger (1998) viewed learning as a social enterprise where the learners, through a progressive interaction of experiences and current knowledge, are guided through and by the learning situations (Cater-steel & Mcdonald, 2017; Cobb, 1994; Scaife, 2012). The learning facilitator provides scaffolding (Bruner, 1966) that enable learners to develop learning within their zone of proximal development (ZPD) (Vygotsky, 1978), thereby progressively expanding learners' knowledge and practice.

With this grounding, Wenger (1998) proposed four premises on learning: our learning experiences rely on the fact that human beings are social beings; knowledge is determined by the competence and values of the knowledge that the 'knower' associates to it; knowledge is produced in the active-participation in its pursuit; and learning progresses as we continuously make meaning of and from the learning experiences. Under these premises, he further proposed four components of learning from a social perspective: **community**, **identity**, **meaning**, and **practice** (see Figure 3.1).

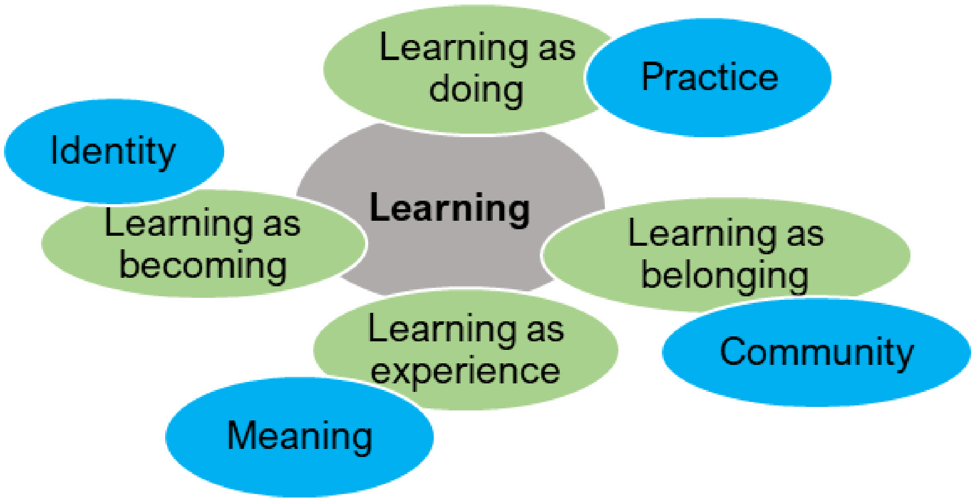

Figure 3.1 Wenger's (1998) components of social learning theory.
Adapted from Wenger (1998, p. 5).

Wenger (1998 p. 5) explained these components as follows:

- **Practice**: a way of and talking about the shared historical and social resources, frameworks, and perspectives that can sustain mutual engagement in action.	**Learning as doing**
- **Community**: a way of talking about the social configurations in which our enterprises are defined as worth pursuing and our participation is recognizable as competence	**Learning as belonging**
- **Meaning**: a way of talking about our (changing) ability - individually and collectively - to experience our life and the world as meaningful.	**Learning as experience**
- **Identity**: a way of talking about how learning changes who we are and creates personal histories of becoming in the context of our communities.	**Learning as becoming**

According to Wenger (1998), when applying this model, learning can be viewed as; doing, belonging, experiencing and becoming (in green in Figure 3.1) **or** as practice, community, meaning and identity (those in blue in Figure 3.1). As such, focus can simultaneously be on the process (those in green) well as the product (those in blue) of learning. This model fits well with how TPL has been conceptualised earlier in Section 3.2 because both consider the individuality, collective contextuality, and the processual nature of learning.

Parker, Patton, and O'Sullivan (2016) explained how this thoery applies to TPL (pre-serivce and in-serivice): important features that shape learning include critical dialogue, sharing learners' predispositions to learning, and exploring mental and cognitive processes of learning. Thus, teachers need to *experience* various pedagogical practices by actively *doing*, engaging, and reflecting on learning that is both individual and in collective. These socially-driven activities involve negotiating meaning of practice to develop experiences that promote communities of leaners in which:

> Participation and reification represent two intertwined but distinct lines of memory. Over time, their interplay creates a social history of learning, which combines individual and collective aspects. (Wenger, 2010, p. 180)

Through these processes, teachers are seen as *becoming* members of communities of learners, practitioners, and inquirers, enabling them to communicate these fundamental social learning values to their students (Parker et al., 2016). Furthermore, such learning gives learners a sense of *belonging* to a community of learners, where collective learning is valued alongside individual subjective learning. Ultimately, through such practices, teachers develop their identity as learners and members of a community of learners and practitioners (Stoll, Bolam, McMahon, Wallace, & Thomas, 2006). The beauty of this theory is that, the elements shown in Figure 3.1 can be transferable across different contexts, providing rich, multi-contextual experiences of TPL. Thus, in this study, social learning theory is applied to develop, explore, and understand TPL in the context of Maldivian primary teachers' pedagogical inquiry into contextualising SPS pedagogies. In the next section, I discuss how a combined thoery is used to understand SPS pedagogies (as a specific constructivist learning theory) and social learning theory can be unified under social constructivist learning theories.

Section 3.4 Combined theoretical framing: *Social constructivist learning*

So far, I have I explored two theories pertinent to this study. In Section 2.3, I have discussed how constructivist learning theories provide a sound theoretical basis to explore SPS pedagogies. The applicability was justified based on the fact that this theory provides much of the needed contextual contingencies for pedagogies that are significant for teachers working in LMIC contexts and for non-specialist teachers of science. This significance resides in the fact that a key tenant of this theory considers learner's prior knowledge and active involvement in the learning process together with the social dynamics of the learning experience. In the previous section, I have explained why social learning theory is useful in exploring TPL because it enables a contextually contingent view of teacher learning that helps us to understand the individual and the social nature of collective professional learning. In this section, I explain how and why these two theories are important to this study in exploring teacher professional learning of pedagogies for SPS. Figure 3.2 presents a visual of how these theories are applied in this study, and how they both have similarities as social constructivist learning theory.

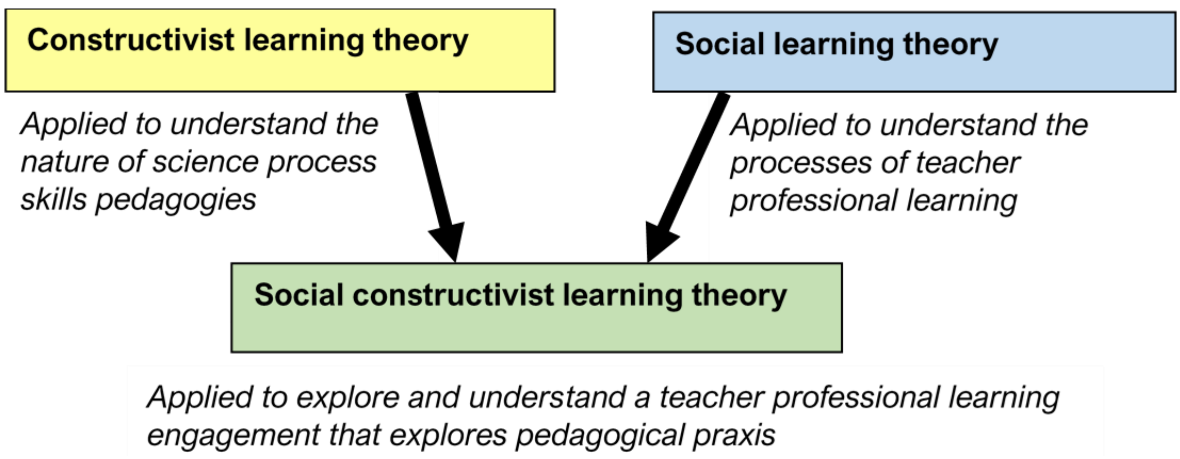

Figure 3.2 Combined theoretical framing.

Constructivist learning theories broadly combine elements of social learning and cognitive learning. This synthesis is useful in learning science because these theories value learning as socially mediated, culturally sensitive, and personally constructed (Windschitl, 2002). As such, according to constructivist learning theory, learning takes place through the interaction of learners' prior experiences and current knowledge; they are guided through the learning situations, which are scaffolded by the teacher (Cakir, 2008; Nola, 1997; Scaife, 2012). However, the paradigms proposed by this theory offer limited explanations for exploring teachers' learning processes as autonomous professionals who work in professional learning communities. As such, while constructivist learning offers a sound theoretical basis to explore SPS pedagogies, the explanatory power it offers for TPL is limited.

Thus, I applied social learning theory as proposed by Wenger (1998) to explore and understand teacher professional learning in engaging in and developing their SPS pedagogies. The most significant premise of this theory is that it is applicable for teacher learning as social interactions and dynamics associated in mediating the learning process (Scott, Asoko, & Leach, 2007).

The linchpin of these two theories is the active nature of learning. As such, learning is 'both a process of active individual construction and a process of enculturation' (Cobb, 1994, p. 13) into the practices of the teaching and learning communities, whether it be pedagogies or professional learning. Kolb (2015) further emphasised that, in such learning processes, both the personal experience and the groups' collective experiences are important. According to Cobb (1994), the combined view of social and individual construction of learning allows us to account for both subjective mental constructions as well as collective socially-mediated processes within teacher professional learning. This combination directs us to socio-constructivist theory, where learning is viewed to be negotiated through learners' internal cognitive processes and is socially and socio-historically situated, wherein 'personal-to-social' mediates the learning process (Adams, 2006). As such, I apply constructivist learning theory to explore SPS pedagogies and social learning theory to understand TPL. As the aim of this research is to explore upper primary teachers' professional learning of pedagogies for SPS, social constructivist learning theory enables me to view these two concepts (TPL and pedagogies for SPS) in tandem. As Kalpana (2014) highlights, the strength of the socio-constructivist theory is that it considers the social context of learning in the knowledge construction process, and hence for this study, this theory informs the exploration of how teachers learn, explore, and apply constructivist theory informed SPS pedagogies in their practice through socially-mediated teacher professional learning activities.

Conclusion

In this chapter, I reviewed the literature to argue for the importance of teacher professional learning as a means to promote democratic professionalism. I have argued the importance of this view because it considers the contextually-contingent learning that moves learning away from often polarising discourses and practices around TPL. From both the previous chapter and this chapter, the combined review of literature made on primary school teachers' professional learning for teaching science reveals an unattended and much needed subject-focussed professional learning niche. This niche exists in many countries across the world, but the need to address it is more urgent in LMICs and small island developing states (SIDS) because the development related challenges that these countries face make them more vulnerable to the unhelpful and uncritical borrowing of educational practices.

Social learning theory was presented as the theoretical lens to explore and understand TPL. A broader theoretical framing of social constructivist learning theory that converges the theory of constructivist learning applied for pedagogies, and social learning theory applied for TPL, is presented to inform the empirical exploration of TPL. To situate and amplify the research problem further, I provide in the next chapter the research context: primary science education and TPL in the Maldives.

Chapter 4. The Research Context

Context does, indeed, matter.
(Crossley, 2010 p.427)

Introduction

The purpose of this chapter is to provide an overview of the research context and expand the research problem. In Section 4.1, I describe some of the economic, geographic, historical, social, and cultural practices prevalent in the Maldives in order to highlight how these features have shaped primary science education and teacher professional learning (TPL) practices in general. I then in Section 4.2 describe the overall education system in the Maldives and the recent changes in the national school curriculum. These features provide the backdrop for the contextual features that will be explained in the next two sections. In Section 4.3, primary science education is specifically discussed through examination of the national science curriculum and the science process skills (SPS) pedagogies that it advocates. In Section 4.4, I examine teacher professional development and learning practices, focussing on pre-service and in-service offerings that are available for primary teachers. Apart from providing the background for this study and the research problem itself, the features discussed in this chapter also help to explain some of the challenges faced during data collection and thus aid in my reflexivity as the researcher.

Section 4.1 The Maldives: An overview

In this section, I consider some of the geographic, economic, historical, social and cultural practices prevalent in the Maldives, to explain how these features impact primary science education and TPL practices in the Maldives. Two aspects are considered. Firstly, features associated with being an LMIC and small island developing state (SIDS) are discussed to highlight how geographic and economic challenges impact the education system. Secondly, the social, cultural, and historical features of the country are discussed to identify how these features impact science education. The impacts will be discussed in the subsequent section.

4.1.1 A lower-middle-income country (LMIC) and small island developing state (SIDS)

The Republic of Maldives, located in the Indian Ocean, next to India and Sri Lanka, is an archipelago of 1190 coral islands, grouped into 26 natural atolls[14], scattered across a length of 820 kilometres from north to south and width of 130 kilometres from east to west (Asian Development Bank, 2015). A map of the Maldives is featured in Appendix A.1. 99.99% of the country is sea because the average landmass of the islands are less than one square kilometre (Athif & Pimenidis, 2009). The islands are flat, rising no more than 1.5 meters above average sea-level and thus the Maldives is one of the lowest-lying, flat nations in the world (Asian Development Bank, 2011; UNDP & The Ministry of Finance and Treasury, 2014). The country's population of 491,589 residents are unevenly distributed over 187 islands (National Bureau of Statistics, 2018). There are 135 islands used as exclusive resort-islands while 128 are used for industrial purposes. Approximately one-third of this population resides in Male', the capital city[15], making the island capital one of the most densely

[14] A term contributed to the English vocabulary from the Maldivian language, *Divehi*. An atoll is a low-lying reef, enclosing a deep lagoon, circular or irregular in shape.

[15] This is the fieldwork site for this study.

populated capital cities in the world (Athif & Pimenidis, 2009; Di Biase, 2016; National Bureau of Statistics, 2018).

Economically the Maldives is classified as a LMIC. The Maldives officially graduated to a middle-income country status in 2011. However, the constraints to its economic development that are typical to small island economies have not lessened (Asian Development Bank, 2015). The main source of income to Maldives is through tourism, fisheries, and agriculture (Ministry of Environment and Energy, 2016). Whilst the growth of tourism sector can account for the notable economic development in the Maldives, the country presently faces a large current budgetary deficit due to its heavy dependence on external aid (Di Biase, 2019; UNDP & The Ministry of Finance and Treasury, 2014).

The geographical 'smallness' of the Maldives classifies it as a small island developing state (SIDS). This characterisation considers different forms of 'smallness' that such countries face, such as population size, land area, and gross national product (GNP), together with development complexities and environmental vulnerabilities[16] (Office of the High Representative for the Least Developed Countries, 2011; UNDP & The Ministry of Finance and Treasury, 2014). However, because of each SIDS's unique socio-cultural history and distinctive ecology, the individual priorities, needs, and dilemmas around education and development vary significantly from global agendas and are even different amongst the other similar SIDS (Crossley, 2010; Crossley & Sprague, 2012; Pillay & Elliott, 2005).

Environmentally, the Maldives islands are highly vulnerable to natural disasters associated with climate change (Stojanov, Duží, Němec, & Procházka, 2017), and it is forecasted that with a rise of one metre in sea level, the islands would be washed underwater (IPCC, 2013). Economically and socially, the country's highly-centralised

[16] Further geographical remoteness, narrow human and natural resources base, heavy external aid dependence, high vulnerability to climate change and natural disasters, and high costs of services such as energy and transportation, are also some of the SIDS features.

government system together with a heavy development focus on the capital city Male' has made it a 'powerful-capital-city', a phenomenon common in small state archipelagos (Royle, 2001). Consequently, a gradient in access to resources and economic development is created (Di Biase, 2016), with a reported difference in quality and access to educational opportunities and resources across the country (Ministry of Education & Ministry of Higher Education, 2019). Further, although the Maldives has overtaken other LMICs in achieving universal primary education in 2002 (Ministry of Planning and National Development, 2005) and maintaining 100% primary school enrolment ratios with no gender disparities[17], the spatial and geographical disparities between one island to the other poses significant and unique challenges in the provision of quality education (Ministry of Education & Ministry of Higher Education, 2019).

Amidst all these unique environmental, economic, and developmental challenges the Maldives faces, the education sector continues to grow and develop and aspire to the international standards of quality (Asian Development Bank, 2011). However, often such aspirations tend to bring in assumptions of 'one-size-fit-all' and 'best-practices' found in global agendas and discourses. Although developmental aid is highly valuable and much needed, the ideologies and practices associated with aid are not necessarily applicable to the Maldivian context and its people (Di Biase, 2016). For example, in 2002, supported by funding from the UNICEF, the Child-Friendly-Schools (CFS) policy was introduced into all public primary schools in the Maldives. This policy strongly advocated LCE ideologies and practices (Di Biase, 2016). However, what was not considered in the implementation was teachers' unfamiliarity to this concept – borne from Eurocentric worldviews and practices (Guthrie, 2018; N. Halai, 2012; Sriprakash, 2010). Thus, it is not surprising that the evaluation of the CFS policy resulted in only superficial changes in schools, such as changes to

[17] In 1990 enrolment ratio in primary education of boys: girls were 86.81:86.71 and from 2002 onwards it has equalised and have remained constant (Education Statistics, Ministry of Education 2007, 2016).

physical design of the classroom, whilst teachers' pedagogical praxis remained unchanged (Di Biase, 2016, 2019).

4.1.2 Historical and socio-cultural context

One of the most significant historical events in the country was the *en masse* religious conversion of Maldivians to Islam in AD 1153, facilitated by the decree of the king. Since then, the sole religion in the Maldives has been Islam; initial literacy and numeracy education in the country has been attributed to the religious-based teaching which accompanied this conversion. Other significant historical events occurred when the colonial powers in the region shifted from Dutch dominance to British rule, when the Maldives started facing British colonial pressures and eventually became a British protectorate in 1887. During this protectorate period, the Maldives transitioned from a monarchy to a republic, experienced several *coup d'état* and periods of political upheaval (Shafeeu, 2019). Independence from the British, gained in 1965, 1965 marks a pivotal moment in the country's history and legacy. The effects of both Islam and British influence have strongly imprinted the fabric of Maldivian society. These effects are discussed in Section 4.3.

The long history of Islam in the Maldives has amalgamated religious practices and associated beliefs into Maldivian culture, traditions, and the society's practices, norms and values (Adam, 2015b). Today, the Maldivian constitution requires all Maldivian citizens to be Muslims. Islamic faith and beliefs are practiced and followed in various aspects such as education, judiciary system, politics, and social lives. Whilst Maldivians have traditionally prided themselves as a moderate Islamic country following a liberal sect of Islam, Didi (2013) observed that the current forces of Islamic extremism is changing these practices, and so Islam has become a divisive factor in the contemporary Maldivian society. Apart from having a common religion, Maldivians also take pride in having one local language, Divehi[18]. Though Divehi is the local language and is used in official communications, English is widely spoken (Mariya, 2012). English is the formal medium of instruction for all schools[19], but Divehi is the medium used to teach Islam, *Qur'an,* and Divehi language. These factors of language and religion are strong, binding factors that help promote social and cultural unity and patriotic values. These features will be attended to in detail in Section 4.3 of this chapter.

In the Maldives, women and men have equally enjoyed democratic representation in society. However, there exists a strong patriarchal tradition in the country where women are expected to be homemakers and men are the breadwinners. It is possible that these expectations are a legacy of our Islamic values and heritage (National Bureau of Statistics, 2014). There is also the expectation that if women become professionals, they go into professions such as teaching or nursing. There are almost three times more female primary teachers than male (Shafeeu, 2019).

I have commented on some features of the history and socio-cultural contexts of the Maldives that manifest in everyday life of Maldivians and have shaped the education system. It is also important to acknowledge here that these features have influenced my identity as a Maldivian and coloured the lenses through which I see the world. Some of these lenses enable me to relate with my participants and, in doing so, present this research from close to home. However, my comparative research orientations have also enabled me to look at these identities and associated discourses with critically, questioning the practices and norms prevalent in science education and TPL in the Maldives.

[18] The origin of Divehi language traces back to Sanskrit and Singhalese and shares common features with Urdu, Arabic, and English.

[19] There is only one (public) school in the country where Arabic is the medium of instruction.

4.1.3 Section summary

In this section, the geographical, economical, historical and socio-cultural features pertinent to the education system in the Maldives were identified. The Maldives' identity as both an LMIC and a SIDS bring about geographical and economic hindrances to quality and equitable education in the country. Further, the Islamic identity together with British influence on the country are critical features that shape the education system in the Maldives. Details on how these features have shaped the education system, in particular science education and teacher professional development and learning are explained next.

Section 4.2 Education in the Maldives

The purpose of this section is to identify some of the contextual features of the Maldivian education system which have determined primary science education and teacher professional development and learning practices.

4.2.1 A historical overview of education in the Maldives

The education system in the Maldives has been influenced by three major forces: *informal education*, which children receive from the family and island community; *Islamic religious instruction*, provided through private tutoring and individualised teaching, and the *formal education* of Western-style English-medium schooling (Latheef & Gupta, 2007). Although Gupta ((2018)) argued that these three systems have led to education evolving from the ‘responsibility of religious leaders and institutions to a nationwide government system of schools’ (p. 22), these three systems of education have created the simultaneous operation of a formal education system in parallel to the informal education system, where one impacts the other in content and form. In fact, though religious education has been formalised and folded into formal schooling, it still dominates the formative school education of every Maldivian child. Of particular interest to this research is the form in which these two education systems have coalesced to precipitate the ‘traditional’ pedagogies practiced in primary schools.

Early-childhood-education (ECE) in the Maldives starts from the informal education system, where children from the age of two years are sent to *Edhuruge*[20] to learn reading and writing in Divehi, Arabic script to recite the *Qur’an,* and basic numeracy[21] and religious prayers (Mariya, 2012). The popular pedagogical approach in

[20] The literal translation of this is “teacher’s house”. This form of education is often conducted in the teachers’ house, but nowadays are run places dedicated for such education.

[21] The arithmetic is taught in *Divehi*, though the numerals used in script are the same as that of English numerals.

these *Edhuruge* is rote-learning where Arabic language is not taught for comprehension but as a means to be able to recite the *Qur'an* (Adam, 2015; Mariya, 2012). Oftentimes, young children, whilst attending these *Edhuruge,* would simultaneously attend pre-school or primary school. The endpoint of this informal system of schooling is when the child completes reading the whole *Qur'an* at least once. The foundation of schooling that starts from *Edhuruge* has sizeable implications for both students' learning styles and the pedagogical practices common at primary school (Duch, 2005; Gupta, 2018).

As discussed in the previous section, there is a strong British influence in the Maldives; one space of influence was their role in shaping the Maldivian education system with the introduction of Western-style, English-medium schooling. The first such school was opened in Male' in 1927, with support from the British power in the region, but the school was limited to boys only. In 1944, the establishment of a similar girls' school in Male' is said to be the first formal step in gender balance in the provision of education in the country (Mariya, 2012). This system was further formalised with the changes to the constitution in 1932, stating that education is the responsibility of the state (UNESCO-IBE, 2011). Once the Maldives got its independence, rapid changes to the education system took place. In 1980, the Ministry of Education (MoE) started gaining control over schooling with a broad mandate to train its citizenry for national development; thus, the first national primary school curriculum was introduced, formalizing English as the medium of instruction in the all public primary schools (UNESCO-IBE, 2011). This curriculum was later revised in 1984 when a national curriculum[22] for middle school and primary school was introduced. For secondary schools, the IGCSE GCSE subject-specific syllabi were used in lieu of a curriculum. As such, there was three discrete curricula documents used in formal schooling, structured on a 5-2-3-2 cycle which included five years of primary schooling (grades 1 to 5) and two years at the middle school (grades 6 to 7), followed by

[22] Primary grades were grades 1 to 5, and middle school grades was grades 6 to 7.

three years of lower secondary school (grades 8 to 10) and two years of higher secondary school (grades 11 to 12) (Mohamed & Ahmed, 1995).

The 1990s brought rapid development to the education system in the Maldives. Neoliberal forces created private schools and introduced international curricula into the country. Religious educators opened an Arabic medium school with support from both Egypt and Saudi Arabia. School enrolment ratios started increasing, and higher education institutions and pre-service teacher education were established. Schools were built in every inhabited island with support from countries such as Japan, or global funding bodies such as World Bank, United Nations, and the Asian Development Bank. During the 1990s, higher education institutions such as the Institute for Teacher Education, the Allied Health Services Training Centre, and the Maritime Training Centre were established. In 2001, these institutions were unified under the umbrella of the Maldives College of Higher Education, and, in 2011, the consortium was officially declared as the first university of the Maldives (The Maldives National University, 2011).

Global forces of education development have also influenced the landscape of education in the Maldives. For example, when UNESCO launched the Education for All initiative and the Millennium Development Goals (MDG), the Maldives embraced both and duly reported on achieving universal access to primary education across the country in 2000 (Ministry of Education, 2008). Further, with local initiatives for basic education and literacy programmes that started in 1980s and continued throughout the 1990s, the Maldives boasts a 98.94% literacy rate, which is impressive when compared to neighbouring countries and all the more impressive for a LMIC.

4.2.2 Education in the Maldives today

In the last decade, the education system in the Maldives has undergone many changes. The biggest change was associated with the advent of a new national curriculum in 2015. Details about this design of curriculum and associated pedagogical changes in the Maldives are discussed in the next section. One of the most significant changes associated with its introduction was changes to the school structure.

The previous grade system was combined with the Key Stage system (see Figure 4.1). Shafeeu (2019) argued that these changes reflected similar changes that took place in England during that time. According to NIE (2011), this restructuring was meant to provide more flexibility in teaching content across the Key Stages and to provide teachers more flexibility in their pedagogies. However, in practice, structural changes such as these brought more uncertainty and increased demands on primary teachers. For example, the grades where generalist teachers work has now increased from grades 1 to 5, to the Key Stages 1 to 3, that is, from grades 1 to 8[23].

Another recent change was aimed at universalising access to both primary and lower secondary education. In 2010, all the primary and secondary schools in the Maldives were restructured to offer grades 1 to 10. Currently, a majority of the 213 public schools teach grades 1 to 10 (Ministry of Education, 2017)[24] and all are fully implementing the new national curriculum. However, with this move of changing school structure, together with limited school size necessitated a two-session school system; 7am to 12:30pm for lower secondary grades (grades 6 to 10/12) and 12:45pm to 5:30pm for primary grades (grades 1 to 5)[25] (Shafeeu, 2019). This two-session schooling system has extensive repercussions for the quality of school teaching and learning (Shafeeu, 2019).

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[23] Key Stage 3 (grades 7 to 8) science is taught by a general science teacher though the curriculum at these grades have specialised science strands; biology, chemistry and physics.

[24] Overall, there are about 213 schools both public and private, offering Primary Education, 195 schools offering Lower Secondary Education (grades 1 to 10), and 52 schools offering Higher Secondary Education (either as grades 1 to12 or grades 11 to 12) (MoE 2018).

[25] Depending on schools there are slight adjustment in these timings, but the overall number of hours in the sessions remain the same.

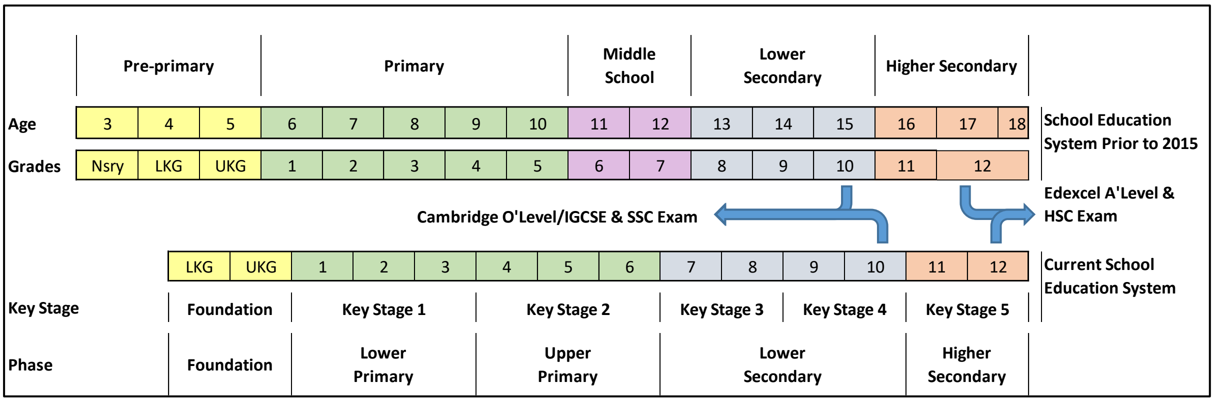

Figure 4.1 School education system in the Maldives.

In terms of class-size and gender ratio in primary schools, as relevant for current context of my research, the average classroom size is 30 students and rarely exceeds 40, with a reported teacher to student to ratio of 9:1 in the capital Male' (Ministry of Education & Ministry of Higher Education, 2019). This ratio varies in island schools where teacher attrition is problematic (Shafeeu, 2019). In 2018, there were 2923 men and 6653 women working as teachers in public schools. This disparity is wider in the primary grades, with 2.65 times more women than men (Shafeeu, 2019). Such numbers demonstrate the popularity of teaching as a female profession. In fact, all participants in this study are women.

4.2.3 The new National Curriculum in the Maldives

In this sub-section, I discuss the new national curriculum, its structure, philosophy and the pedagogical approaches it subscribes to. This exploration lays the foundation for later exploration of how science education component of this curriculum prescribes SPS pedagogies.

To unify the previously fragmented school curricula and address the demands of a globalised world, in 2003, the MoE decided to introduce a new national curriculum. A new, outcomes-based-education (OBE) curriculum mapping school education from Kindergarten to grade 12 (students of age 6 years to 18 years) and emphasising skills and competencies was thus formulated. The development of this curriculum took over a decade and in 2015, the curriculum was introduced into all public schools, starting from Key Stage 1, with an incremental addition of one Key Stage each year thereafter. The National Institute of Education (NIE)[26] published three important documents to support the implementation of this curriculum: The National Curriculum Framework, Key Competency Guide, and Pedagogy and Assessment Guide. While none of these documents offer an explicit reason to why an OBE approach to curriculum design was adopted, according to Spady (1994), such curriculum shifts embody rhetoric of 'modernist tendencies' (p. iv) in contemporary schooling. In the Maldives, this tendency is intensified by an unhealthy obsession of following and (uncritically) borrowing education practices from countries such as Australia, the UK and the USA.

According Ministry of Education & Ministry of Higher Education ((2019)), the mission of the new curriculum is:

> To provide opportunities to all girls, boys, youth and adults, to acquire knowledge and skills, as well as nurture in them values and attitudes, to thrive and actively participate in nation building, and live as responsible global citizens in an interconnected world. (p. 12)

According to NIE (2011), this curriculum provides schools and teachers with a thorough framework, starting from broad educational visions to assessments and accountability measures, mapping the whole school-learning experience seamlessly across all grades and Key Stages. According to NIE (2015):

> These key competencies provide the basis for lifelong learning and employability in a progressive and challenging world. Each key competency is built on a combination of cognitive and practical skills, knowledge, values, attitudes, dispositions, and other social and behavioural components. (p. 2)

These statements highlight a skill-development emphasis common to most OBE curricula (Guthrie, 2015), and, resonating a key principle behind OBE, it assures its audience 'that all students are equipped with the knowledge, competence, and

[26] The official body responsible for planning and developing the national curriculum.

qualities needed to be successful after they exit the educational system' (Spady, 1994, p. 9).

For implementing this curriculum, the school academic year consists of two terms of 20 to 22 weeks each. Schools have class-specific weekly timetables allocating subject-specific teaching sessions or periods. At the primary grades, a school day has seven such periods. For primary science, most schools currently have five 35-minutes periods per week. This curriculum requires English as the medium of instruction for all subjects except Islam, *Qur'an* and Divehi language (as mentioned earlier, these subjects are taught in Divehi). The teachers at these grades are either generalist teachers or specialised teachers: specialist teachers deliver the subjects of Islam, Divehi, and *Qur'an*, while generalist teachers are required to teach mathematics, science, social studies, and often physical education, music, arts, and crafts—in essence, the majority of the curriculum. Typically, primary teachers teach 20 to 26 periods per week. Most of the primary teachers in the Maldives hold a minimum qualification of a teaching diploma (Ministry of Education, 2015), attained either as a 2-year diploma or 1-year diploma, for entry with GCSE/IGCSE O-Level pass or entry at A-Level pass, respectively.

4.2.4 Section summary

In this section, features of the education system in the Maldives have been described to explain how its history together with recent changes are defining school education today. In particular, the country's Islamic heritage plays a significant role in shaping education practices in the Maldives. Similarly, in an attempt to comply with the neoliberal and globalisation forces, the Maldives have introduced an OBE curriculum borrowed heavily from Eurocentric countries. The effects of these two forces on primary science education and TPL practices are discussed in the next two sections.

Section 4.3 Primary science education

The purpose of this section is to explain primary science education practices as a backdrop to develop the research problem for this study. This section elaborates on the features highlighted in the previous two sections, which have identified the country's geographical, economic, historical and socio-cultural features and how these features have shaped the current school education system. As such, this section explores the implications of these features on primary science education. In particular, this section is structured to compare the pedagogies as per Nind et al.'s (2016) three dimensions of pedagogy as discussed in Section 2.2.3. The first section explores the dimension of *pedagogies as **specified*** in the curriculum to understand how SPS pedagogies are prescribed in the curriculum. In the next part, the dimension of *pedagogies as **enacted*** and *pedagogies as **experienced*** are discussed, highlighting how the contextual features from earlier in this chapter precipitate change in teachers' pedagogical practice.

It is important to acknowledge that this section and the next are developed based on a limited literature base as research on these areas (science education pedagogies and teacher professional development and learning) in the Maldivian context is scarce. The research base is limited to unpublished research dissertations, and consultation papers conducted for international agencies or those commissioned by the government.

4.3.1 Primary science in the National Curriculum – *pedagogy as specified*

Since formal primary schooling began in the 1960s, science education has always been important in school education in the Maldives (Shareef, 2016). At the beginning of formal schooling and because of limited local curriculum materials, textbooks developed for Caribbean countries or Singapore[27] were used. These textbooks, a proxy for curriculum, determined the pedagogy, scope, and sequence of the content delivered and assessments implemented. However, when a locally-developed national primary science curriculum was developed in the 1980s, science as a subject was reintroduced as 'Environmental Science' (ES). Shareef (2010) explained that the rationale for this change was to facilitate the teaching of environmental education concepts in combination with the natural sciences. ES was taught in primary grades 1 to 5, and at middle school grades 6 to 7, where it was referred to as General Science (GS), a combination of chemistry, biology and physics concepts. The purpose of GS was to provide students a flavour for the science subject to inform their subject choices for IGCSE/GCSE studies at secondary grades (Shareef, 2010). Schools would allow students to pursue science at the secondary grades if only they achieved a pass mark in middle school science. Thus, the GS was content-heavy and teachers followed its sequence rigidly.

During the curriculum revision stages, it was believed that the sciences need a more explicit focus in the primary grades and labelling it as 'Environmental Science' defeated the purpose of the primary science education (Ismail, Head of Science Curriculum Development, personal communication, 10/1/17). According to the science curriculum, 'the aim of science education in the Maldives is to develop scientific literacy' (NIE, 2015a, p. 6). As discussed in Chapter 2, similar aims for science education are common across the world.

Another significant feature of the new primary science curriculum (referred to as syllabus in these documents) is its structure. It is composed of four content-strands and two process strands. The content strands determine the content, scope, and sequence, while the process strands articulate the processes to be used in teaching. The content strands are Life and Living; Earth and Beyond, Matter and

[27] My primary science education was based on these textbooks.

Materials, and Energy and Change. The process strands are Science and Technology and Working Scientifically (see Figure 4.2). The rationale for such categorisation is that, in the implementation of the subject matter, teachers will integrate the science content with the aspects most appropriate from the process strands (NIE, 2015a).

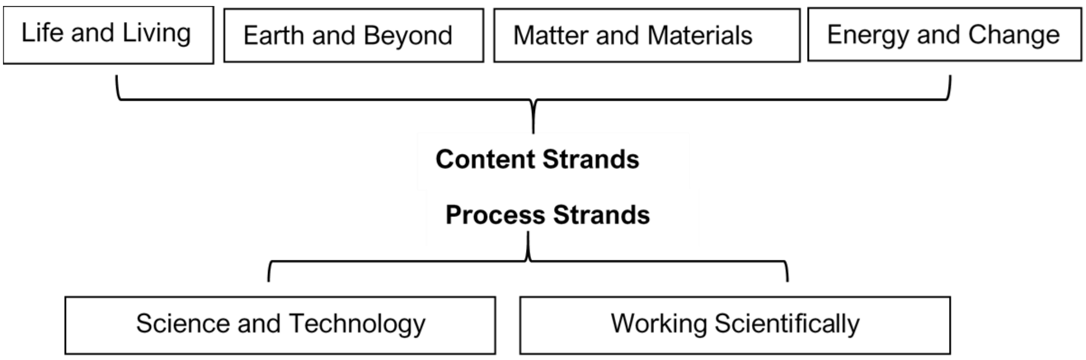

Figure 4.2 The strands in the science curriculum.

This study focusses on the Working Scientifically strand because this strand highlights the SPS, as seen in NIE curriculum documents:

> This strand looks into ways of creating students' natural curiosity and sense of wonder about their world, as they participate in experiences that enable them to explore, predict, clarify their ideas, ask questions, test explanations and conduct their own research. (NIE, 2015a, p. 9)

Further, according to the science syllabus the process skills are described in the curriculum as:

> a range of practical skills that need to be acquired by the students. Some of these fundamental skills include: Observing, Classifying, Recognising patterns, Estimating and measuring, Questioning, Making and testing, Predicting, Investigating and experimenting, Recording and communicating, [and] Designing and making. (NIE, 2015a, p. 9)

These SPS are congruent with those skills discussed in Section 2.3.2, except in the skills of 'recognising patterns' and 'making and testing'. It can be argued that 'recognising patters' in similar to 'describing relationships' (see Chapter 2, Figure 2.3) and 'making and testing' is similar to 'experimenting' (see Chapter 2, Table 2.1 and Figure 2.3). The syllabus does not explicitly classify these skills into basic or advanced skills as literature on these skills commonly do, nor do they offer a sound definition of these skills for teachers. However, as in shown in Figure 4.3 below, the way the outcomes and indicators are categorised implies different levels of SPS.

Strand: Working Scientifically

Sub-strand: Observation, Questions & Hypothesis

Outcome WS1.1:
Makes observations and selects appropriate scientific information to make predictions/hypothesis

Indicators:
This is evident when the student:

a. Uses appropriate tools in making observations.
b. Uses appropriate vocabulary to explain events/phenomena
c. Recognises that there can be more than one explanation for a set of data.

Sub-strand: Investigations

Outcome WS2.1:
Conducts simple investigations

Indicators:
This is evident when the student:

a. Formulates investigative questions.
b. Identifies variables in an investigation.
c. Plans procedures in carrying out simple investigations.
d. Collects data using appropriate tools.
e. Uses appropriate units in measurement
f. Organizes data in appropriate ways.
g. Proposes ways to improve the investigation.
h. Analyses data to identify trends and make conclusions.

Figure 4.3 Science process skills in Working Scientifically strand.
Adapted from NIE (2015a, p. 72).

Figure 4.3 is also provided to illustrate how these skills are expanded at the grade level syllabi, as pedagogical prescriptions (the excerpt provided is from the grade 6[28] syllabus). It can be seen that the indicators list the skills without providing to the user much support on how these skills are connected, nor information on how they are to be used in the teaching of the science content. It can be argued that curriculum prescriptions like these also assume that the users will have the necessary background knowledge about these skills and their relationship to each other. This problem gets exacerbated further by the heavy load of content prescribed in the science syllabus. To illustrate, in Table 4.1, I tabulate the number of outcomes per each content strand in the grade 6 science syllabus.

Table 4.1 Outcomes/content strand in Grade 6 science syllabus.

Strand	*Life and Living*	*Earth and Beyond*	*Matter and Materials*	*Energy and Change*
No. of outcomes in Grade 6 science syllabus	**12**	**15**	**6**	**9**

With three to four indicators for **each** of these outcomes, there is an excruciating demand put on teachers to 'cover' content outcomes like running a race. While such unrealistic curriculum expectations have profound implications on students' learning, the demands made on generalist primary teachers, who are teaching science out of their specialism, presents a significant problem.

[28] Grade 6 is also relevant because this is the grade that participants in phase two were teaching.

The science syllabus explicitly specifies the pedagogies to teach science. According to the curriculum, LCE based active learning pedagogies will enable students to make meaning of the science knowledge, skills, and values, which

> arouses interest and curiosity, creates a love for science, provides room for creativity and imagination, offers opportunity to reflect critically and make sense and meaning of their experiences. (NIE, 2015a, p. 13)

Specifically,

> Instructional settings and strategies should create an environment which reflects a constructive, active view of the learning process. (NIE, 2015a, p. 13)

On the basis of literature reviewed in Chapter 2, what is evident in these statements is that the science curriculum in Maldives subscribes to progressive constructivist pedagogies for science education. This is evident in the reference to ‘active, constructive’ pedagogies in these curriculum documents. As argued in Chapter 2, such active, constructivist approaches go hand in hand with teacher agency and autonomy, though LCE pedagogies are often misused and misinterpreted in LMICs because of various discourses and ideologies around such pedagogies. In the highly centralised education system that currently exists in the Maldives, questions arise regarding the feasibility, practicality, and enactment of progressive constructivist pedagogy. The mandated use of a nationally-developed textbook and teachers’ guide which rigidly prescribe the science content and pedagogies also raises questions on the *amount* of teacher autonomy and agency available for teachers implementing the science curriculum.

Taken all together, the expectations placed on primary teachers in teaching science are unrealistic and create incongruences between the curriculum’s expected pedagogies and those that are possible and available for primary science education. In the next sub-section, I expand more on these pedagogical incongruences by discussing pedagogical practices and norms prevalent in the Maldives.

4.3.2 Pedagogical practices – *pedagogy as enacted and pedagogy as experienced*

In this section, I explore pedagogies prevalent in primary schools to understand these tensions further to illuminate on and problematise the gap between the *pedagogies as prescribed* and *pedagogies as experienced* to explore the tensions between the science curriculum as prescribed and the science education as possible.

According to Mohamed (2006) and Nazeer (2006), a common pedagogical tradition in most primary and secondary classrooms in the Maldives is the focus on discipline and 'being quiet'. Because such tactics minimise classroom management issues, such practices are favourable in schools and the Maldivian education system tends to determine a teacher's effectiveness based on their ability to maintain discipline among their students (Mohamed, 2006). The prevalence of these practices can be attributed to the Islamic religious education system and associated pedagogies for religious-based rote-learning that children are exposed to at an early age (Adam, 2015; Di Biase, 2016). In Muslim communities, learning to recite the *Qur'an* and Islamic faith-based teachings produces a long history of passive, formalistic pedagogical practices involving listening, memorisation, and regurgitation (Talbani, 1996), together with dogmatic preachings that promote religious beleifs and practices[29]. Observing from the Omani context, Al-Balushi and Ambusaidi (2015) explained that Islam influences cultural understandings and can in turn impact science learning and teaching approaches, where science learning is used as means to deepen one's religious faith. According to Guthrie (2003, 2011, 2018, 2020), such faith-based pedagogical practices represent a revelatory epistemology. which differ from scientific epistemology; under revelatory epistemologies, 'knowledge is based on revealed truths' (Guthrie, 2020, p. 36) passed on from previous generations and

[29] For example, I remember being told never to question anything about God (Allah) and his presence, because such queries will make you an unbeliever.

associated with religious ideologies. Conversely, in scientific epistemologies, 'knowledge is created through scientific enquiry' (p. 35).

Adam (2015b) explained that in the Maldives, similar pedagogical practices have heavily influenced the formation of teachers' pedagogical praxis. While some authors such as Di Biase (2019) argue that these practices have evolved over time to make way for contemporary progressive teaching methods of active learning, Adams (2015) offers a contestation using Talbani's (1996) observation that in predominantly Muslim countries, pedagogical change tends to be minimalistic and fragmented. Despite progressive reform, religious-based traditional, authoritative pedagogies persist in teachers' overall pedagogic repertoire. Mohamed (2006) reported about such persistence with an anecdote from her own experience: after more than ten years away from classrooms, she walked into an English class to observe a lesson which was conducted in exactly the same way that she had experienced as secondary student herself.

Another factor that contributes to authoritative pedagogies in the Maldives is **teachers' own schooling experiences** (Adam, 2015). It is simple human nature that people tend to default to teach as they were taught (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010), so a reason for the prevalence of traditional practices is because most of the teachers come from traditional classrooms themselves (Adam, 2015; Di Biase, 2016). Although pre-service teacher training provides opportunities to learn and practice contemporary teaching methods, the minimal teacher-student(s) contact-hours in these programme does not provide sufficient time for such changes in teachers' practice (Foulds & Rowe, 1996). Similarly, s**chool culture** and the context of the schools where teachers work also contribute to the prevalence of traditional teaching practices. Nazeer (1994) observed more than 25 years ago that the MoE views good teaching as good results in the examinations and any teacher who helped produce good results in the examinations became 'the school hero' (p. 192); I hold that similar ideas still persist today. He further observed that these competitive practices foster harmful individualism and unhealthy competitions between schools, students, and teachers.

Another common practice in schools is the use of **'one-size-fits-all' lesson plans** that are handed to individual teachers by their leading teachers, with little or no revisions made from its previous implementation (Mariya, 2012; Mohamed,). So, over time, changes in teachers' pedagogies are minimal. In teaching science, these lesson plans are highly structured and revolve around the content of science curriculum; a common misinformed practice is that all the content identified in the curriculum for a year group must be completed within the year itself, ignoring the vertical and horizontal connections in the curriculum (Mohamed, science curriculum developer, personal communication, 10 Jan 2017). As discussed in Chapter 2, such lesson planning practices are common where generalist teachers are teaching outside their specialism.

All of these factors manifest in primary science education pedagogies and result in examination-oriented, teacher-centric, expository methods of content-laden (Adam, 2015; Di Biase, 2019; Fittell, 2014; Mariya, 2012; Shareef, 2010) and formalistic traditional pedagogies (Guthrie, 2018). Guthrie (2020) explained that formalistic traditional pedagogies rely on passive student behaviour, where teachers make them remember a 'curriculum of basic facts and principles' (p. 38). Fittel (2014) similarly described a typical science lesson in a Maldivian primary classroom as:

- Teacher presents a set of facts.
- Children do a group activity that records those facts.
- Groups report back on the facts and are judged right or wrong.
- Children individually record the set of facts in books or a test sheet. (p. 64)

This common practice of science teaching heavily relies on the textbook and dogmatically utilises textbook facts. Consequently, the assessments are heavily geared to parroting the content stated in the textbook, as observed again by Fittel (2014):

> When I looked at tests that teachers were preparing, they required students to memorise exact statements from textbooks, rather than more general applications and understanding of topics. (p. 64)

The implications of such formalistic pedagogies are noteworthy here. A national study conducted in 2014 with all students of grades/years 4 (ages 9 to 10), 7 (ages 12 to 13) and 9 (ages 14 to 15) reported that students' conceptual understanding of scientific concepts was low (UNICEF & NIE, 2014). Even lower were scores in high order thinking and skills-based questions when compared with international standards. This result shows that both students and teachers are not familiar with the application of SPS into different learning contexts. According to a curriculum developer, Maldivian primary science teachers do not teach basic SPS such as observing, measuring, and investigating, which is evident in the teachers' heavy reliance on content-based pedagogies (Mohamed, science curriculum developer, personal communication, 10/1/17).

4.3.3 Section summary

The purpose of this section was to explain primary science education pedagogies in order to compare the dimension of *pedagogies as **specified*** in the curriculum with *pedagogies as **enacted*** and *pedagogies as **experienced*** by the teachers hypothetically implementing that curriculum (see Nind et al., 2016, referenced in Chapter 2). The comparison of the two indicates a glaring gap; *pedagogy as **prescribed*** are progressive and constructivist, while *pedagogy as **experienced*** are formalistic and traditional. It can be argued that teachers and students in the Maldives are familiar to formalistic pedagogies due to Islamic religious education practices, teachers' schooling experiences and school culture, which combine to maintain traditional formalistic pedagogies. Further, policy imperatives such as the use of single-text books, 'one-size-fits-all' lesson planning compounded with various forms of teacher passivation practices in the education system tightens and promotes formalistic pedagogies. Thus, introduction of an OBE curriculum without any form of contextualisation is a move towards uncritical transfer of SPS pedagogies.

We cannot simplify and attribute this gap to teachers' ignorance of curriculum-prescribed progressive pedagogies; doing so echoes a managerial professionalism discourse which censures teachers and unjustly demeans the profession at large. The question that arises, then, is how can SPS be taught at primary science in the Maldives, where the purposes of the science curriculum is achieved and taught consistent with the nature of science but employing pedagogies available for teachers? As Barrett (2007) argued, we need to consider the ‘values and ideas regarding teaching and learning and their efforts to put these into practice’ (p. 292) and acknowledge that teachers’ pedagogical palette is mixed. As argued in Chapter 2, viewing pedagogies as a **praxis** and a **process** allows us to consider dynamics, flexibility, and contextual contingencies, all of which can be explored together with teachers through participatory research approaches where teachers can engage in the pedagogical praxis associated with professional learning.

Apart from illuminating contextual pedagogies for SPS, such a professional learning engagement can also inform mechanisms through which generalist primary teachers’ pedagogies for SPS can be supported and enhanced. As such, the next section attempts to understand the background of teacher professional development and learning practices in the Maldives.

Section 4.4 Teacher professional development and learning

The previous section concluded by identifying a gap between *pedagogies* ***specified*** and *pedagogies as* ***experienced***, with respect to the science curriculum and in particular to teaching SPS. One possible reason for this gap was argued in Chapter 2, in that prescribed pedagogies are not contextually relevant for teachers' classroom realities. To explore such contextually relevant pedagogies, TPL on pedagogies offer an important avenue to understand pedagogical relevance. In Chapter 3, it was argued that teacher professional development (PD) and TPL promote different conceptualisations of teacher professionalism. To understand contextual contingencies on pedagogies and to promote democratic teacher professionalism, TPL engagements and activities connected to teachers' pedagogical praxis offer a holistic, participatory, and situated inquiry.

The purpose of this section is to explore current practices of teacher professional development and learning to inform the development of a TPL inquiry for this study. First, in this section, pre-service professional development practices are explored to highlight teachers' limited exposure to SPS. Next, in-service teacher professional development practices are explored to understand the norms and practices teachers are offered; this review will help to identify the types of learning activities that can be designed to offer professional learning that supports teachers' pedagogies.

As with research on Maldivian science education, research on teacher professional development and learning in the Maldives is a field of inquiry that needs expansion in order to establish a situated evidence base. Although research interest in this field is slowly emerging, the studies that are currently available are limited to research dissertations and consultation papers from international agencies or the government. Across these reports, there is a preponderance of a singular paradigmatic perspective. Consequently, though the focus of this study is on primary teachers and SPS pedagogies, in this section I present the broader local literature base on TPL to set the background for this study.

4.4.1 Pre-service primary teacher education

The first public institute dedicated for formal pre-service teacher education (Institute for Teacher Education, ITE) was established in 1984; this institution offered pre-service teacher education for generalist primary (grades 1 to 5) teachers and specialised middle-school (grades 6 to 7) teachers. Initially, these trainings were run as certificate-level qualifications and, in 1996, offerings were expanded into a diploma-level course[30]. In 2004, the first bachelors' level teacher training programme was established for pre-service primary teacher education. Over the years, this programme has undergone various revisions; today, it is still run at the Faculty of Education at Maldives National University (MNU). All of my participants in both phases of this study gained at least one of their teaching qualifications from MNU.

By 2010, the global wind of neoliberal ideologies had led to privatisation (Gupta, 2018) of higher education in the Maldives, with several private institutions providing pre-service primary teacher education. In all these institutes, pre-service primary teacher education is offered at the bachelor's level, with units in educational and instructional psychology, content-upgrade units (mathematics, social studies, physical and health education and arts and crafts), teaching methodology, and a 15- to 20-weeks teaching practicum period. However, as observed and practiced in many African countries with similar developmental and economic challenges (Akyeampong, Lussier, Pryor, & Westbrook, 2013), in the Maldives there is still no strong alignment between the in-service teacher training curriculum and the primary school curriculum in terms of pedagogies (The Maldives National University, 2016).

Over the past five years, the basic qualification for being a teacher in the Maldives has formally risen. In 2014, the government required all the teachers in the

[30] According to the Maldivian Qualification Authority's classification system a certificate level course is equivalent to grade 7 and Diploma course is equivalent to grade 10.

Maldives to have a minimum qualification of a Diploma in Teaching; this qualification was later updated to a minimum of a bachelor's qualification or equivalent (Ministry of Education, 2014). To cater to the geographical dispersion of the population of potential pre-service teachers, since 2016, most of the teacher education institutions in the country have shifted to flexible modes of delivery. Currently, blended-mode, block-mode, and online-mode pre-service primary teacher education is common[31]. Though this shift was made for practicality and accessibility purposes, the shift has heated up debate around the quality of the pre-service teacher training that is being provided, with the current Minister of Education advocating to stop block-mode pre-service teacher education, calling it 'inadequate' and compromising quality of teacher education in the country (Mihaaru News Maldives, 2019). This is just one example of shifting political ideologies that plague the Maldives education system.

The standard entry criteria for a pre-service primary teacher education programme at the bachelor's level is two passes at GCE A-Level or equivalent, with five passes at GCE O-Level/SSC including Divehi and mathematics, along with certified proficiency in English or satisfactory performance in a written test of English (UNESCO-IBE, 2011). A potential pre-service teacher might then come in with two A-level passes, for example, in Economics or Mathematics having done business-stream subjects in his/her GCSEs. As discussed in Section 2.4.4, this entry criteria is problematic when training generalist primary teachers, especially in specialised subjects such as science (N. Halai, 2012). For example, a pre-service teacher with a business background might have had formal school science up to grade 7, and this pre-service teacher will get a basic content-upgrade[32] in science in their pre-service programme and is expected to teach science at the primary grades using 'new and novel ways of teaching science that espouse a constructivist way of thinking about

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[31] Of the phase two participants, two of them did their Bachelors of Primary Education through this mode, one was doing a Bachelor degree in Primary Education at the time of data collection.

[32] This content is focussed on the primary school science curriculum.

knowledge' (N. Halai, 2012, p. 390). This hypothetical situation is the background for most of the teacher participants in this study. The implications on generalist teachers working outside of their specialism areas were discussed in light of science education literature in Section 2.4.4. and Section 3.3.4 and discussed in relation to the context of the Maldives in this section.

4.4.2 In-service primary teacher professional development and learning

In the Maldives, the first in-service teacher professional development policy was formulated in 2009; to this day, it is still in place. According to this policy, the annual academic calendar allocates three separate days for dedicated professional development (PD), where the PD is to be self-initiated at school level, based on a school-based teacher needs-analysis (Ministry of Education, 2009). This policy stipulates that all schoolteachers are required to participate in a minimum of 15 PD hours annually. Since the implementation of this policy, all schools in the Maldives have been running their school-based PD both independently and in association with the Ministry of Education.

With the formulation of the PD policy and in order to make PD accessible for teachers, in 2009, with support from the UNICEF, Teacher Resource Centres (TRCs) were established in each of the atolls (Di Biase, 2016; Amita Gupta, 2018). The TRCs are located in the governing-central island of the atolls. These centres were to be the hub for teachers' PD, collaboration, and networking, developing local resources and teaching materials for the schools in the region. Another aim of establishing these centres was to make PD provision accessible for teachers from all over the country (O'Shaughnessy, Nock, & Bishop, 2009). Prior to this establishment, for PD purposes teachers had to travel to the capital Male' or the PD provider from Male' had to travel to the islands in order to conduct PD. This practice meant almost 80% of the training cost was simply for transport (InfoDev, 2010). However, evidence regarding the reduction of this cost due to the establishment of TRCs are contradictory, O'Shaughnessy et al. (2009) observed. They reported that teachers who use these TRCs prefer to travel to Male' rather than the TRC islands, simply because inter-atoll travel is expensive and travelling during monsoon times is more expensive and difficult. Further, due to lack of trained staff at these TRCs and their low popularity as a destination for PDs, the TRCs are yet to achieve the goals to function as hubs of/for teacher professionalism and decentralisation of PD.

Another common ill-practice of teacher PD common in the Maldives is the belief that PD can only be run by external experts (Di Biase, 2016; Nazeer, 1994; Saeed & Moreira, 2010) This form of dependency on external support trivialises the value and importance of local teachers' expertise and knowledge, which is significant in the direct implementation of the curriculum. Further, as discussed in Chapter 3, whilst experts have the knowledge of the curriculum or the pedagogies, they are not aware of how either are translated in classroom contexts and thus fail to relate them to teachers' every day work.

PD that is focussed on the curriculum started in 2012 and intensified around the introduction of the new curriculum. Most of these PD sessions focussed on training and orientating teachers to the curriculum: its prescribed competencies, assessments, and how to use online platforms to track students' progress via curriculum outcomes and indictors. Another form of curriculum-related PD was the training-of-trainers. First, the curriculum-developing authority trained a few trainers from across the country. Due to the financial limitations of travelling to Male', from different islands across the country, PD opportunities tended to be limited to the grade-leading teachers. The objective is that, following their initial training, these trainers could thus become curriculum ambassadors who conduct school-level PDs for their colleagues. Most of the training on the primary science curriculum has been conducted this cascading format (Mohamed, science curriculum developer, personal communication, 10/1/17). As discussed in Section 3.2, these forms of PD are based on transmissive models premised on 'deficit-models' that subscribe to managerial forms of teacher professionalism (Fraser, Kennedy, Reid, & McKinney, 2007; Kennedy, 2005).

Teachers who have been in such transmissive-style trainings have reported their dissatisfaction on the mode, content, and form of PD. According to Naseer (2018) and Saeed and Moira (2010), teacher PD that is conducted in the Maldives has not been very productive for the teachers. These authors reported that there is a mismatch between teachers' aspirations for PD and the opportunities for PD they have available. Oftentimes, PD take form of conventional workshops or another lecture-style delivery of information where the PD provider will talk *at* the teachers and the teachers listen passively (Naseer, 2018). Such practices are far removed from teachers' immediate classroom realities, resulting in teachers' loss of motivation to undertake PD (Di Biase, 2017).

Conclusion

This chapter has foregrounded the background for this study. I have discussed how the socio-cultural dynamics of the country's past and present educational practices have brought in global influences such as an OBE science curriculum prescribing the use of progressive constructivist pedagogies. However, the literature reviewed in Chapter 2 reveals that progressive pedagogies may be contextually incongruent to teach science process skills, but constructivist pedagogies *do* offer contextual contingencies relevant for teaching SPS in contexts such as the Maldives. In this chapter, then, it has been argued that because of the contextual incongruences of progressive pedagogies, there exists a concerning gap between the curriculum-prescribed pedagogies and the pedagogies that are experienced by teachers, especially for generalist primary teachers in teaching SPS. This study works to address this gap.

The literature reviewed in Chapter 3 set out a view of professional learning as activities that promote democratic teacher professionalism and enable teacher autonomy and agency necessary to contextualise pedagogies in teacher praxis. As explained in the current chapter, this concept contrasts with the form of teacher professional development opportunities available in the Maldives, where transmissive PD trainings are the norm. These transmissive PD activities, together with insufficient pre-service opportunities limits individual teachers' pedagogical praxis associated with the development and application of SPS. Without such opportunities, generalist primary teachers exhibit limited pedagogical palettes, further aggravating the previously mentioned gap between *pedagogy as prescribed* and *pedagogy as experienced*.

Thus, this research explores TPL and contextualisation of science process skill pedagogies in tandem. In particular, this research develops insight into the situated processes of generalist primary teachers' professional learning associated with exploring the contextual contingencies offered by the constructivist pedagogy of a science-investigation-based-approach (SIBA) to teaching science. The next chapter presents the research design for this inquiry.

Chapter 5. Research Design and Process

> Teacher knowledge generation (teacher research) depends on teachers finding ways of sharing critical experiences. The tacit experiences must be made explicit if we are to consider alternative frames of reference that may lead to deeper understanding of teaching and learning.
>
> (Loughran & Northfield, 1996, p. 131)

Introduction

The aim of this research is to explore upper primary (Grades 5 to 6) teachers' professional learning (TPL) of pedagogies for science process skills (SPS). In the previous chapters, I have reviewed relevant literature to conceptualise SPS pedagogies and TPL, and I have contextualised these concepts within primary science education in the Maldives to explain the research problem I address in this study: *the need to explore contextually contingent pedagogies for SPS through a professional learning engagement*.

This chapter explains the research methodology I used to address this research problem. There are three parts in this chapter. In Section 5.1, I explain the research paradigm: how an ontology of subjectivism and epistemology of social constructionism has informed the research design. Further, I explain how this paradigm enabled a sequential participatory research methodology informed by the 'Teachers as Researchers-Movement' (Cochran-Smith & Lytle, 1999). In Section 5.2, I explain the research process, data collection/gathering methods, and data analysis procedures. Finally, I conclude with Section 5.3 where I discuss questions of positionality, reflexivity, reciprocity, research trustworthiness, and both situational and procedural ethics.

Section 5.1 Research paradigm

This section explains this study's ontology, epistemology, and methodology. According to Castellan (2014), the above mentioned elements determine the *research paradigm,* or our worldview. Explicating the elements of our research paradigm is important because our ontological and epistemological decisions provide the basic structural layer of research (Creswell, 2007). Good research is not simply about arguing which research paradigm is best but selecting an appropriate paradigm for the inquiry and how we justify these decisions (Graue & Karabon, 2013). The ontological, epistemological, and methodological decisions I took in relation to this study are discussed in detail below.

5.1.1 Ontology: *Subjectivism*

Grix (2004) defined ontology as 'claims and assumptions we make about the nature of social reality, what exists, what reality looks like, what are their units and how do these units interact with each other' (p. 59). As discussed in Chapters Two and Three in this study, this study conceptualises SPS pedagogies and TPL to be subjective, relative, and contextually contingent. This view acknowledges the subjective multi-nature (Guba & Lincoln, 1994) of these practices, together with the acknowledgement that truth, reality, and rationality of these practices need to be understood as situated-in and situated-through the socio-cultural context that gives meaning to these elements (Denzin & Lincoln, 2018; Saldaña, 2011).

As such, knowledge about SPS pedagogies and TPL are not in the minds of individuals, but they are manifested in the multiple and subjective social relationships we formulate, engage in, and sustain (Gergen & Gergen, 2008). Thus, there are multiple and subjective realities of SPS pedagogies and TPL, and any attempt to study these can only bring us close to a partial reality of these concepts because the practices continuously and subjectively evolve as we experience them (Crotty, 1998).

5.1.2 Epistemology: *Social constructionism*

Denzin and Lincoln (2018) explained that epistemology speaks to assumptions about knowledge and knowledge production and thus stem from our ontologies. Epistemology focusses on the origins and nature of knowing or theory of knowledge, with profound implications for the relationship between the researcher and the participants (Cohen, Lawrence, & Morrison, 2007; Graue & Karabon, 2013; Maykut & Morehouse, 1994). Following an ontology of subjectivism, I applied an epistemology of social constructionism in this study. Crotty (1998) explained that

> knowledge and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of the interaction between human beings and their world, and developed and transmitted within an essentially social context. (p. 42)

Following such an epistemological stance in this study assumes that the process of understanding pedagogies and professional learning are not objective but are based on and result from the active and cooperative enterprise of the teachers and the social relationships between them (Gergen & Davis, 1984; Gergen & Gergen, 2008). It has been argued that pedagogy and TPL is processual and contextually contingent (Chapter 2 and Chapter 3, respectively). Thus, social interactions together with the individual and collective meaning-making processes are critical avenues in understanding teachers' SPS pedagogies and teachers' professional learning (Bryman, 2012; Gergen & Gergen, 2008; Saldaña, 2011). Further, learning, thinking, and knowing about pedagogies and professional learning are contingent on the socio-cultural interactions and dynamics that teachers engage in, negotiate with, and make meaning of/from (Wenger, 1998). Thus, my positioning in this research as an 'insider' as a local researcher familiar with the socio-cultural norms (Mcness, Arthur, & Crossley, 2015) of teachers' practices in the Maldives further enabled this epistemological orientation to this study. This positionality is discussed in detail at the end of this chapter.

Guba and Lincoln (1994) argued that in social constructionism research, the researcher and the researched are interactively linked and the findings evolve as the research progresses. Constructing knowledge in this way places significance on my role as the researcher and how I interpret the teachers' realities of SPS pedagogies and professional learning. Thus, it is inevitable that the interpretations I make on the teachers' experiences about SPS pedagogies and professional learning will reflect some of my prejudices, biases, and predispositions (Beuving & de Vries, 2015; Bogdan & Bilken, 2007). Thus, I acknowledge the 'value-laden nature of facts, the interactive nature of inquiry' (Denzin & Lincoln, 2018, p. 196) that is this research and thus the need for researcher reflexivity. In Section 5.4.1, I explain how I managed such reflexivity throughout this study.

5.1.3 Methodology: *Sequential participatory teacher research*

Research methodology refers to the general logic and the theoretical perspective a researcher imbues in the study (Bogdan & Bilken, 2007). According to Howe and Moses (1999), the methodological choices stemming from a social constructionism epistemology should:

> seek out and listen carefully to "voices" embedded in their social context to gain a true understanding of what people are saying and why they do what they do. And dialogue itself has consequences: Beliefs, culture norms, and the like are not just there, waiting to be uncovered, but are negotiated and "constructed" via the interactions among researchers and those they study. (Howe & Moses, 1999, p. 36)

This means my methodological choices have to enable me to work closely with primary teachers in order to understand their *SPS pedagogical practices* and *professional learning experiences*, paying attention to the language, voices, practices, and interpretations relevant to these concepts. Postholm (2012) argued that in socio constructivist research on pedagogies and TPL, the researchers' role is to support teachers and to develop teachers' pedagogical praxis by asking critical questions to guide the reflections and experiences that develop teachers' praxis. Such a supportive role necessitated the adoption of an exploratory nature in this study in order to further understand and explore the contextual nature of the research problem. This situated nature of the study prompted me to adopt a sequential design to further understand and explore the research problem.

As such, the study has two phases. First phase, which I refer to as **Phase One, sought to identify the status quo on SPS pedagogies and TPL in primary science education in the Maldives**. Data was gathered from 14 generalist primary teachers across eight different schools, three science curriculum developers, and three science teacher educators. Findings from this phase were used to inform the design and development of the teacher professional development and learning activities of the second phase, which involved the implementation of these activities with four primary teachers in one school. **The purpose of the second phase, referred to in this study as Phase Two, was to map generalist primary teachers' professional learning and associated pedagogical changes through a pedagogical-inquiry-based professional learning engagement.** Data generated from multiple methods (see Figure 5.1) were analysed using a narrative thematic analysis approach.

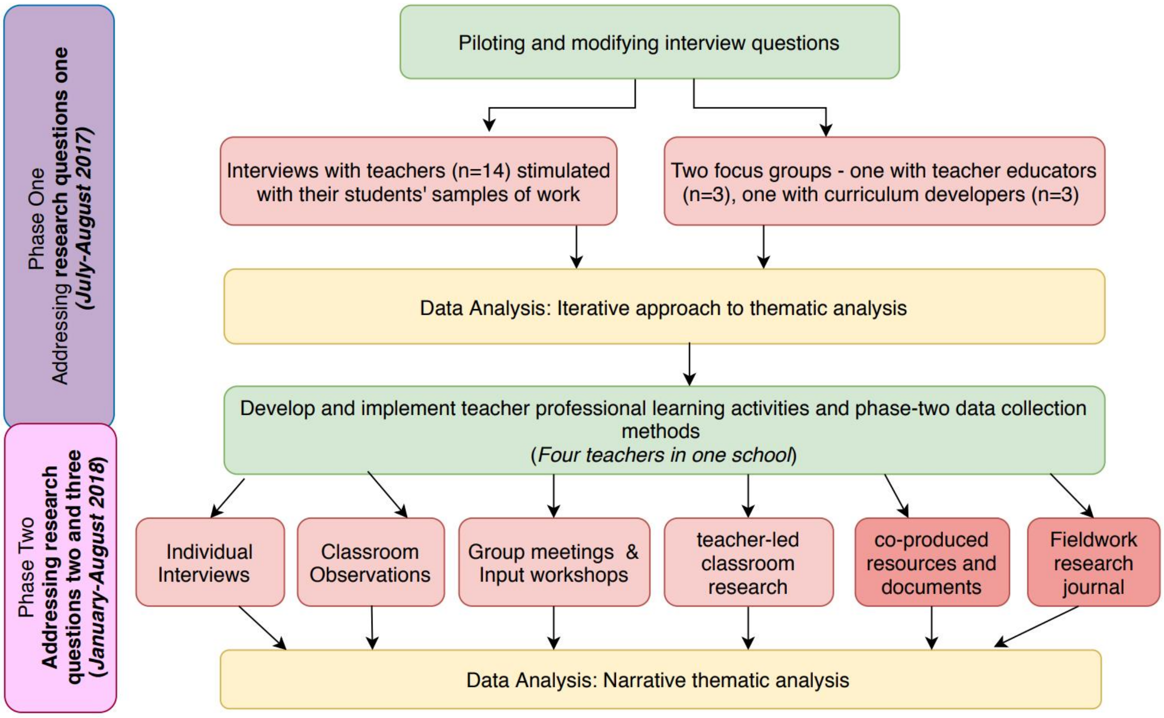

Figure 5.1 Overview of the research process.

Within the two-phased sequential study, I maintained a participatory approach to research with particular roots in the Teachers as Researchers-Movement (Cochran-Smith & Lytle, 1999), which is premised on the notion that development of academic knowledge about schooling is not only for 'university-based-academics', but data should be collected in co-operation with/by practitioners (Zonne, 2007, p. 72). According to Cochran-Smith and Lytle (1992), 'the teacher-researcher movement is based on the notion that a professional plays a participatory role in the creation and use of knowledge in the field' (p. 303). This methodology can be considered as *participatory teacher research,* and I have adopted this methodology for this study because, as per the subjectivist ontology and social constructivism epistemology, the only way to understand and explore teachers' professional learning practices of SPS pedagogies is to work with them. Here, teachers lead the research trajectories and, as the researcher, my role will be to document and facilitate the TPL processes.

Teacher research is sometimes referred to as action research or practitioner inquiry; these terms are often used interchangeably (Check & Schutt, 2011). However, in this study, I maintain that 'all action research conducted by practitioners can properly be termed teacher research, but not all teacher research can properly be labelled action research' (p. 264). Further, the ideals of teacher research are premised on broader ideals of teacher empowerment through bringing a collective set of their stories, practices, and voices to the forefront (Check & Schutt, 2011; Cochran-Smith & Lytle, 1993, 1999), where the latter is significant for identifying contextual contingencies in teachers' practice.

Cochran-Smith and Lytle (1993; 1999) defined participatory teacher research as a systematic and intentional inquiry that is carried out by practicing teachers. Mohr et al. (2004) elaborated on this by defining teacher research as 'intentional, systematic, public, voluntary, ethical, and contextual' (p. 23). A more comprehensive definition by Check and Schutt (2011) viewed teacher research as a broader label to describe all kinds of school and classroom based research that is conducted by practitioners. This definition is of value to the current study because the mode of inquiry that I employed in this study was that of an educational practitioner (myself) approaching practicing teachers with a research problem to be problematised and explored further using participatory research methods. As discussed in earlier chapters in this thesis, the research problem I address in this study is the *need to explore and practice contextually-contingent pedagogies for SPS through a professional learning engagement.*

Thus, in this study I apply participatory approaches to understand generalist primary teachers' SPS pedagogies and how teachers navigate their professional learning experiences in translating *pedagogy as* ***prescribed*** into *pedagogy as* ***enacted*** and *pedagogy as* ***experienced***. The main place where I heavily make use of participatory teacher research methods is in the second phase this study. The teachers' professional learning (TPL) engagement was premised on collaboration and developed based on social learning theories (see Section 3.4) to provide avenues to collectively problematise classroom practice and to contextualise pedagogies, taking into consideration the local cultures and politics (Windschitl, 2002) in teachers' practice. Such collaboration and the collective nature of TPL development impacts emergent theories of instruction and has the potential to evolve into useful practices (Darling-Hammond, 1996). Furthermore, a number of studies indicate that collaboration holds promise for TPL (Cochran-Smith & Lytle, 2014; Little, 2002; Ronfeldt, Farmer, McQueen, & Grissom, 2015).

Another feature of participatory research method which appeals to me for this study is that this research methodology views **participants as co-researchers**. 'Co-researchers work together with an academic researcher while carrying out an intentional inquiry that stems from or generates questions and reflects the desire to make sense of classroom-life experiences' (Zonne, 2007 p. 78). According to Stenhouse (1985), such a practice-oriented mind-set implies that in teacher research, unlike conventional research, researchers should justify themselves to practitioners, not vice-versa. As such, teachers as co-researchers extends teachers' roles in research to active participants, subjective insiders, and inquirers who are leading the research's trajectories and thus have ownership of the research process and products (Zonne, 2007) through establishing interdependent relationships. Thus, working collaboratively with the teachers as co-researchers in this research has enabled me to bring the teachers' contexts and multiple realities of SPS pedagogies and TPL. Table 5.1 below summarises this research paradigm.

Table 5.1 Research design overview.

Inquiry level	General assumptions	Application in this study
Ontology	***Subjectivism*** Reality is relative, subjective, socially constructed, experience-based and is mediated by our senses. Thus, there is no single truth, and we can never know the 'whole-truth' but can garner a subjective 'partial-truth'.	SPS pedagogies and professional learning are subjective and multiple realities of these two concepts/practices exist. How one teacher engages, learns, and understands SPS pedagogies and TPL is subjective and relative.
Epistemology	***Social constructionism*** Knowledge is constructed in social interactions through language and other symbolic materials giving it the collective meanings we associate to these interactions.	The knowledge, meaning, and value of SPS pedagogies and TPL can be explored through close interactions between the inquirer (me) and the participants (teachers as co-researchers).
Methodology	***Sequential participatory teacher research*** Research design is systematic, collaborative, and collegial, as such flexible, contextually contingent and applicable research designs are appropriate.	I draw on participatory research approaches to develop a two-stage sequential study. Phase One explores current teaching practices of pedagogies and teacher professional development and learning. Phase Two is based around a professional learning engagement to explore teacher's use of a constructivist pedagogy for SPS and TPL in tandem

Section 5.2 Methods of data collection and analysis

This section details the methods used in each of the two phases. In Section 5.2.1, I explain the participants, data collection methods, and analysis for Phase One, and in Section 5.2.2 I explain these details for Phase Two. The two phases are presented separately here because apart from them being conducted as two different stages and periods of this study (Data collection for Phase One was from July to August 2017, and for Phase Two was from January to August 2018), the data collection methods and analysis were different and driven by different aspects of this research. A brief summary of the process has been previously presented (see Figure 5.1).

5.2.1 Phase One: Exploring existing practices

The purpose of the first phase was identify the status quo around SPS pedagogies and TPL in primary science education in the Maldives. I explain the research participants, data gathering methods used and how the data was analysed for this phase.

The participants.

There were three different groups of participants in this phase: generalist primary teachers (14) from eight different public schools across the country, teacher educators (three) from Maldives National University (MNU), and science curriculum developers (three) working at National Institute of Education (NIE). Table 5.2 lists their background information relevant to this study. The teachers were the focus of this phase because I was interested in understanding their pedagogical practices and professional development experiences. The teacher educators and curriculum developers were included to contextualise teachers' practices, and to aid my reflexivity in the research process, because, as expressed in Section 1.2, I am a teacher educator and a curriculum developer in the Maldives.

I chose to interview teachers from public schools that were accessible to me but were also geographically diverse. In qualitative research, such purposive sampling provides maximum insight and understanding of practices (Ary, Jacobs, Sorensen, & Walker, 2014). Public schools were chosen because they are under the Ministry of Educations' (MoE) jurisdiction to implement the national curriculum. I requested to recruit primary teachers teaching science at grade 5 (11-12-year-olds) because at this level, the curriculum has substantive scientific concepts for SPS-based teaching. When I approached the schools of my choice, I requested from the schools to contact all their teachers in grade 5. The eight schools that participated included five schools from Male' (capital city), one school from greater Male' region, one school from central Maldives, and one from North Maldives. The fourteen participating teachers had a diverse background in terms of teaching experiences, qualifications, school contexts, and teaching responsibilities. There were three novice teachers (NT) who were on their first year of teaching, seven teachers who had teaching experience of more than five years (ET), and four teachers who are science coordinators (CT). The CTs are often teachers who have a science teaching background. These background details are summarised in Table 5.2.

The teacher educators and curriculum developers were my colleagues, however, I sought permission from the relevant gatekeepers[33]. Although there are other institutes in the Maldives which train primary science teachers, I chose MNU because I was familiar with the institution as my previous workplace, and MNU is the oldest teacher training institute in the Maldives, so I could access veteran science teacher educators. There were three science curriculum developers in the Maldives at the time of this research and they all participated in the study. In Section 5.3 I discuss how interviewing colleagues can be both beneficial and ethically problematic.

[33] These gatekeepers are, The Maldives National University (MNU) for the teacher educations and National Institute of Education (NIE) for the curriculum developers.

Table 5.2 Participants in Phase One.

Experience category	Name	No. of years in teaching	Highest qualification completed	Place of work
Novice teacher (NT) – less than 1 year in teaching	**Diana**	Less than 1	B.Ed.	School D (*public school in Male*)
	Ceema	Less than 1	B.Ed.	School C (*public school in Male*)
	Enaz	Less than 1	B.Ed.	School E (*public school in Male*)
Experienced teacher (ET) – more than 5 years in teaching	**Aneega**	5 plus	B.Ed.	School A (*public school in greater Male*)
	Beena	10 plus	Dip.Ed.	School B (*public school in Male*)
	Dhaha	20 plus	B. Ed.	School D (*public school in Male*)
	Cary	6 plus	B.Ed.	School C (*public school in Male*)
	Faheema	12 plus	M.Ed.	School F (*public school in Male*)
	Geela	15 plus	Dip.Ed.	School G (*public school in North Maldives*)
	Heena	10	Dip.Ed.	School H (*public school in Mid-Maldives*)
Sconce Coordinator fo the grade (CT)	**Bathool**	10	M.Ed.	School B (*public school in Male*)
	Dheena	20	B.Ed.	School D (*public school in Male*)
	Faiha	3	B.Ed.	School F (*public school in Male*)
	Hala	12	Dip.Ed.	School H (*public school in Mid-Maldives*)

Teacher educator (TE)	**Ifham**	25	M.Ed.	Science teacher training
	Jeela	25	M.Ed.	Science teacher training
	Kamana	25	M.Ed.	Science teacher training
Curriculum developer (CD)	**Lana**	10	M.Ed.	Science curriculum development
	Mina	10	M.Ed.	Science curriculum development
	Nahula	25	M.Ed.	Science curriculum development

Data generation methods.

In this section I explain the multiple sources of data that were collected in Phase One. These sources were students' samples of work, teacher interviews prompted with the work-samples, and the focus groups with teacher educators and curriculum developers.

Samples of students' work. Once the teachers consented to participate in this research, I requested from each teacher to share with me photos of three students' work from a science lesson in the current academic year, one in which the lesson had focussed on teaching SPS. The students' work samples were used for two purposes. Firstly, they were used to provoke discussions in the interviews because these samples of work helped teachers ground and discuss their practices based on authentic classroom practices; and they also allowed me a window to view teachers' pedagogical praxis from their perspectives. Secondly, the work samples also provided a different data source for data triangulation purposes (Denzin, 2009) to 'allow counter patterns as well as convergence' (Lather, 1986 p. 270) in the data and findings, thereby establishing data trustworthiness. Although using students' work as insight into teachers' practice may provide a limited view into teachers' pedagogical praxis, these samples enabled me a glimpse into teachers' SPS pedagogies.

Interviews with teachers. The purpose of these interviews were two-fold. Firstly, it was to gain an understanding from teachers' perspectives around how they conceptualise and teach SPS. Secondly, it was to identify teachers' experiences of teacher professional development and learning with regard to teaching science and SPS.

I had initially decided to use semi-structured interviews and students' samples of work as two separate and non-related data sources. However, during the piloting process (May-July 2017), I discovered that using the students' samples of work to provoke the discussions during the interviews, made the conversation more constructive, enabling a richer and deeper view to explore the reasons behind teachers' pedagogical decisions and practices. (Avraamidou & Zembal-Saul, 2005).

Semi-structured interviews were chosen for this phase because of the flexibility and the conversational nature that this interviewing structure provides (Ary et al., 2014). Having a set of broad pre-planned questions provided me the flexibility to adapt the questions (Punch & Oancea, 2014) based on the specific pedagogical practices that the teachers were sharing with me. I met all the teachers in their respective schools, often in their staffrooms, at a time that the school agreed was acceptable for interviewing. Due to the geographical dispersion of the islands, travelling to the North of Maldives would have been time consuming and costly; as a result, these two interviews were conducted via Skype. The rest of the twelve interviews were conducted face-to-face. The interview questions that functioned as a guide for the interviews are provided in Appendix A.4.

Although classroom teaching and the interview questions were in English, the interviews were conducted predominantly in Divehi*,* our mother-tongue, because teachers normally converse amongst themselves in Divehi. Further, using Divehi allowed me a better sense of the teachers' practices because conversing in their most comfortable language enabled them to freely express themselves (Halai, 2007). However, most teachers switched back and forth from Divehi and English during these audio-recorded interviews. I discuss the implications of this dual language on this research in Section 5.3.3.

Focus group interviews with teacher educators and curriculum developers. Two focus group interviews were conducted: one with the teacher educators and the other with curriculum developers. A focus group was suitable here because of the nature of these groups of participants and my familiarity with them; their views were mostly used to contextualise teachers' practices and aid my reflexivity. Further, I was seeking from them a collective view of teachers' SPS practices rather than an individual's view (Cohen et al., 2007). In both focus groups, we conversed in Divehi and audio recordings were made.

This method of data collection made economical use of time, but discussing teachers' practices based on my colleagues' collective observations also enabled a progressive discussion of practices where each colleague was able to reflect on their experiences and expand based on what was said by their colleagues (Bogdan & Bilken, 2007). In each of these focus groups, because I used to be part of these groups, discussing these views came easily and, despite the fact I had some questions to manage these interviews, the discussions evolved with a conversational style, a common phenomenon when interviewing colleagues (Coar & Sim, 2006). The conversational nature of the group interviews allowed my colleagues to share deeper insights and thoughts with me which they may not have shared with an outsider (Coar & Sim, 2006). However, interviewing colleagues did pose ethical dilemmas to me, especially during the data analysis stage, because I had to treat my colleagues' utterances analytically and be reflexive regarding my own positionality in this process. These issues are discussed in Section 5.3 in this chapter.

Data analysis.

Analysis of students' work samples and teacher interviews. To familiarise myself with the data, I listened to the interview audio-recordings several times before transcribing. The multiple-listening helped me to identify which parts of the interview to focus on and to further identify relevant excerpts from it. During transcription, translation was kept minimal until final stages of reporting so that the original contextual meaning could be maintained. As I transcribed, I sorted the responses of each teacher into a semi-fixed grid on Excel (see an excerpt of the table in Table 5.3) organising the answers by interview questions for each participant.

This grid visually organised the data according to the interview questions, taking into consideration that some interview questions were not asked for every single participant (Tayler-Powell & Renner, 2003). The grid also enabled me to look for patterns through horizontally comparing and contrasting the data to identify patterns (Miles, Huberman, & Saldaña, 2014) of SPS pedagogical practices and professional learning experiences. As such, the overall analysis involved categorical aggregation and a search for correspondence and patterns (Avraamidou & Zembal-Saul, 2005) based on the different SPS evident in the teachers' interviews and their students' work-samples. For example, in Table 5.3 I have marked in red, some of the skills the teachers expressed in discussing their practice.

Such a horizontal thematic analysis enabled 'identifying, analysing and reporting patterns (themes)' (Braun & Clarke, 2006 p. 79) relevant to pedagogies for SPS and teacher professional development and learning. For SPS pedagogies, I looked for common SPS that were reported by the teachers in their practice, narrowing down to search for these skills in the data.

For example, when I looked at the answers to the interview question '*What are the SPS that were taught in the lesson?*', I compared the responses from all the 14 teachers and identified the list of skills they have identified. These skills were informed by the literature reviewed in Chapter 2. Further, these skills were then categorised based on the level of the skills, as per the categorisation identified in Chapter 2. Thus, two sub-themes – *Basic SPS* and *Integrated SPS* – were identified.

Similarly, students' samples of work were first analysed independently from the interview data to identify the different SPS they presented. These skills were similar to those identified in the interviews. For example, student's work-sample from Bathool shown in Figure 5.2 showed skills of observation and classification which was later grouped under *Basic SPS*. Thus, further analysis of the samples of work was made together with interview analysis. Finally, this sub-theme was categorised under the theme *Pedagogies practiced,* a theme informed by the conceptual framework for pedagogies presented in Section 2.2.3. Figure 5.3 provides a visual of this sequence in the analysis.

Table 5.3 Excerpt from the data analysis grid.

Questions	Diana	Aneega	Faheema	Geela	Hala
Background	primary 1-5	mostl primary 1-5	mostl primary 1-5	mostl primary 1-5	mostl primary 1-5
No. of yrs	1 yr	6	6	17	
Qualification	B.Ed	Dip. Ed	M.Ed	Dip. Ed	
Current practices of teaching science process skills					
a. What are the science process skills that was taught in this lesson?	Observation and predictions	**observation** bodah focus kuree	First **investigation**, some **measurement** involved. Last year they did dho **experiements**, so now bodah focus kuree **recording**.	**observation** was focused	2 years of experiencing the new science curriclum, first year of teaching science **discussed pesticides and the effects of it and how we can enrich soil and how plants can be grown from it.** *Kudhina ingey dho scoil ge kalhu kula ithuru kuran alhan vee thakeythi..* so we discussed them in class
c. Can you describe how the lesson was conducted?	A field trip lesson on predicting and weather where students went to Villingilli. Before they **predicted** what it would be like (based on info??) and then went and **observed**. Did the worksheet in the text book. Drew what the weather was like. Intergrated with social stuies	we let go of the students to go the beach and collect any thing they see. They bring this to class, **observe** it and **classify** them . In groups they did.	then why and how we are doing the experiment. They wrte the steps as we did it and they worked in groups (7-8). **Measure** and they all took same in all groups so that they will get similar reuslts. (NOT COMPARE??). Students wrote their own steps. I first explained. then they wrote. **Obervation** ves liyan	students **observed** the demonstration I did and then noted these observation	I **observed** how students were actually adding the right amounts of materils, qustioned why they were adding what they were addigng. The class did two set-ups, some **measured** the tree growth and then we noted in the class record tabel which all students recorded. we showed them a video of how compost can be done as a way of enriching soil (regarding the topic title), but as a way to get students interested and motivated in the lessson we decided to get teh students to make compost in the class.
f. How was this lesson planned? What resources did you refer to in the planning?	planning was done with the idea of integrating topics of weathering, climate changes. To cover it all in a field trip. It was organised first to go and **observe** the tides, **observe** the surrondings and visit to STELCO, (they did a presentation,) and it was related to a lesson to come later	we don't teach the lesson first. **We ask questions, we get them to predict first**.	We asked them to put water into the soil samples andthen calculated the percentage. Explained what observation is in terms of descriptive and make a **conclusion** based on their aims. Because this is their first such lesson I was not that strict on this part even though I mentioned this in class.		
g. What went well in this lesson you think?	Students enjoyed and it was their first field trip so very happy about it. Assessment was done on the content and worksheet they gave	doing **a discovery type lesson** was the best. The students were very interested throughout. Unlike numeracy and literacy if **explained** in **Dhivehi** they can still understand and then they can stil participate in the lesson	students were engaed in the lesson. Best was tat they were able to **measure** the water volumes. Assessment was done to checking to see their level of **observations** (WHY NOT MEASURING??). It was done as continous assessment. There are varying students. So weak students was done twice, and explaiend to them in Dhivehi and it helped the students because they 'got' it.	I have done this lesson last year the same way. Students don't realise that this is how reain is formed so seeing it in class made it more real for them	students discussed the different things required to enrich soil and then identified materials that can be used to do it and then brought these materials from home the next day (eg, ash, fruit peel and waste) and made the compost themselves and then **observed** and drew how it look like..then a week after they obsrved and drew what it looked like and **recorded** in a table. how the materials they added to it loook like now. SO on the next week they did the same, added water and **observed** to see the color changes and how it was decomposing. We discussed everyday how and why these chnags were takign place. On fourth week it was badly decomposed and on fifth week we planted a seedling in it and now we are observing the growth of the plants. **I asked how the plants growth was being monitered "Balaanee kihaa varakah hedhotho' asked how if they were going to measure and said using a ruler and making the measurements.**
h. What things and how will you improve this lesson for the next time you teach it?	improve on content	I have improved from last time making this time it more structured giving a table for the students to fill	Students skills improve now. When we say **observation** they do know what It means		

Though each teacher presented work from three different students, there was not much difference in the substance of work between the three students from the same teacher. For this reason, in the analysis, to keep data manageable, one student's work-sample was analysed for each teacher, together with their interviews. In presenting the findings from these data, the work-samples are offered together with interview data. When presenting the work-samples, I have used callout boxes to provide my analysis and interpretations of them; as in Figure 5.2 below.

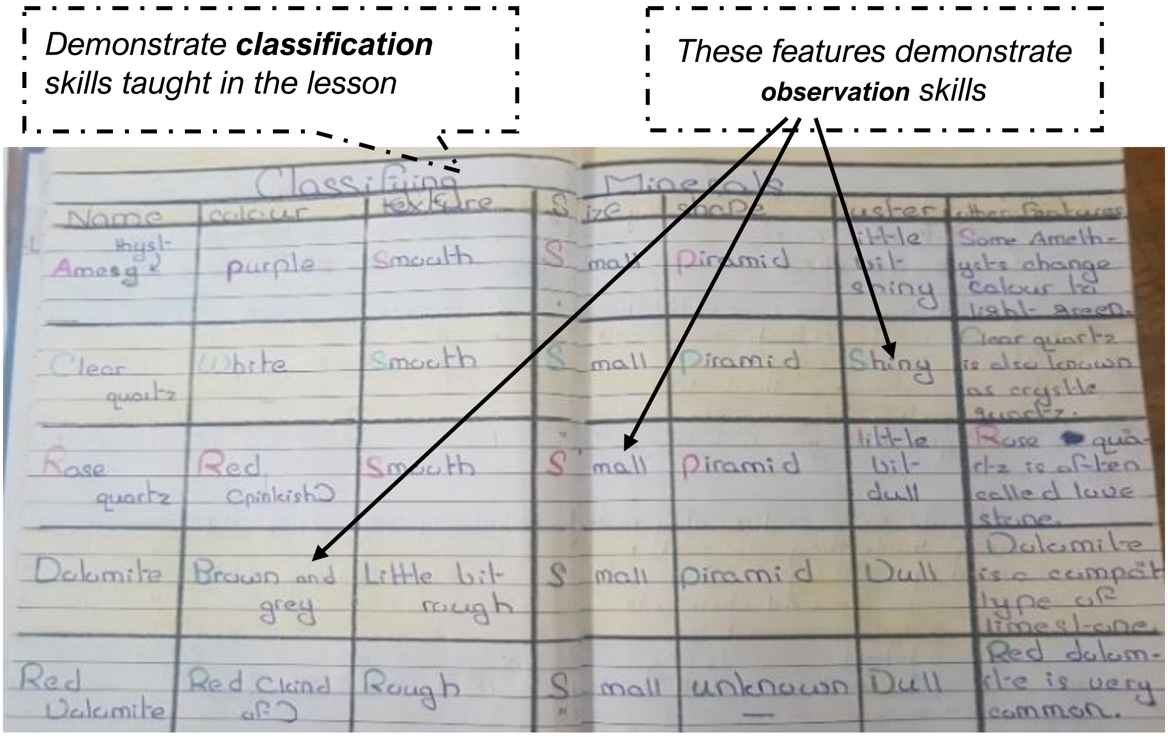

Figure 5.2 One of the students' samples of work from Bathool.

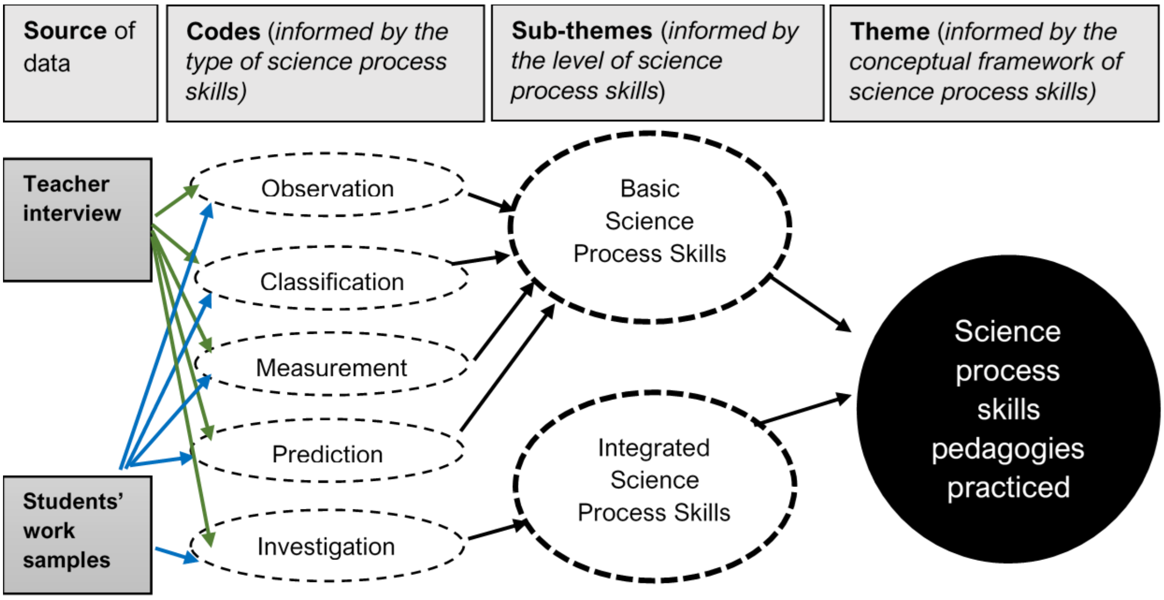

Figure 5.3 Sequence in data analysis in Phase One.

Analysis of focus group interviews. The focus group audio recordings were translated as I transcribed them in English. This was because although our conversations were mostly in Divehi most terminologies related to teachers' practice were in Divehi and I felt confident in translating these conversations because my 'insider' status as a local and with these two groups of participants allowed me a better and stronger understanding of our conversation. Only the excerpts relevant to SPS pedagogies and teacher professional development were transcribed.

As described previously in this chapter, focus groups were conducted to contextualise the existing practices of SPS pedagogies and teacher professional development. Further, as this data set was not very large, rather than organising or reducing it through coding, the analysis was integrated into the process of writing the finding so that teacher educators' and curriculum developer's discourses on teacher practices could be presented and situated to foreground the data from the teachers. Thus, these data are presented in the relevant sections in the findings to highlight teacher educators and curriculum developers' views on teachers' pedagogical practices, professional development provisions, and experiences, where I also work to be reflexive in the reporting of this data.

5.2.2 Phase Two: Implementing teacher professional learning activities

The purpose of the Phase Two was to map generalist primary teachers' professional learning and associated pedagogical praxis through professional learning engagement. In this section, I present the participants of this phase, the data gathering methods as embedded in the TPL engagement, and how this corpus of data was analysed.

The participants.

The focus of this phase was to obtain rich data that is situated through working with a small number of teachers (Adams, 2017) to understand teachers' pedagogical practices for teaching SPS and professional learning through a pedagogical inquiry. I decided this would be best achieved if I worked with teachers from one school because I wanted all participating teachers to be able to attend and engage in the professional learning activities with minimum disruption to their daily schedules (Earthy & Cronin, 2008). I also wanted to model professional learning activities that a school could initiate for their teachers (Lassonde & Israel, 2010).

Thus, I decided to work with School D from Phase One of this study. This choice was made because, during Phase One, this school's principal and leading teachers expressed interest in participating in the second phase of this study[34]. Additionally, the school has high expertise on teaching for Key Stages 1 to 2 as the school had initially started out as a primary school. Thirdly, during Phase One, I had observed in this school the existence of a strong collective school-culture, and such a pre-existing culture of supportive collegiality was going to be favourable for my professional inquiry (Ronfeldt et al., 2015). Although the teachers in Phase One

[34] While I was collecting data for phase one of this study, School D's principal requested from me that I conduct a PD session on science investigation, for their primary teachers (grades 1 to 7). The interest to participate in the phase two of study was expressed during this PD session.

were teaching grade 5 (11 to 12-year olds), for this phase I decided to work with teachers teaching grade 6 (12 to 13-year olds) because most of the teachers who had participated in Phase One were now teaching grade 6, and grade 6, like grade 5, was still in the same Key Stage (Key Stage 2).

As discussed in Chapter 5, cultural norms in Maldivian schools necessitated that I work with all the teachers of one grade level rather than select a few, so I requested that all the five class teachers teaching grade 6 science in School D be my participants. They all consented; however, two-thirds into the data collection period, one teacher resigned, reducing the participants to four. These four generalist teachers had a wide range of teaching backgrounds and experiences favourable to promoting the interactions that facilitate a collective pedagogical inquiry (Lesh, Kelly, & Yoon, 2008). Table 5.4 presents a summary of these teachers' backgrounds as relevant to this study.

Table 5.4 Background information of teachers in Phase Two.

Participating teachers (pseudonym)	Educational qualification attained	Teaching experience (total)	Teaching experience (science)
Dhaha	Bachelors of Primary Education	More than 22 years	More than 10 years
Dhalia	Diploma of Primary Education (*doing a Bachelors' of Primary Teaching via block mode*[35])	More than 15 years	Less than a year
Dheena (*Science coordinator (CT)*)	Bachelors of Primary Education (*doing a Master's in Education via block mode*)	More than 20 years	More than 20 years
Dhasya	Bachelors of Primary Education (*doing a Master's in Education via block mode*)	More than 20 years	Less than a year

[35] See Section 2.7 for implications of this mode of teaching for teachers' professional development.

Data generation methods.

The process of collaborative inquiry generated different types of data on teachers' pedagogies for SPS and professional learning activities (Cochran-Smith & Lytle, 1990) from different sources. Multi-source data generation helps to increase the trustworthiness of the data and findings (Ary et al., 2014) and also helps to bridge the theory-practice gap (van Driel et al., 2001). Most of the data generation sources/methods were also professional learning activities. Thus, as the researcher and the professional learning provider, I was heavily and actively involved in all these data generation activities. For example, I participated in some of the classroom lessons as a co-teacher, I was part of the group discussion meetings, and I also contributed heavily to the co-produced resources. This involvement is conducive to participatory research (Avgitidou, 2020) and promoted teachers' trust in me as a researcher rather than seeing me as an evaluator. Details of my involvement are discussed later in this chapter, and their implications presented in the findings in Chapter 7. Almost all our verbal communications (except classroom teaching) were in Divehi and co-produced written documents were in English. The implications of this duality of language are discussed in Section 5.5.1.

I employed both passive and active methods of data collection. Collecting and co-producing documents such as teachers' lesson plans and schemes of work and making notes and audio recordings of teachers planning meetings were the passive methods because these activities were school-initiated and not conducted for the benefit of my research. Individual interviews, classroom observations and associated pre-post interviews, and teacher-led classroom-research were the active methods. In addition to these primary data sources, the data were constantly corroborated from my field-notes and research journal. I discuss these methods in detail in the subsequent sections in this chapter while Table 5.5 provides an overview of these data generation methods.

Table 5.5 Different sources of data gathered in Phase Two.

Data gathering/collection method	Purpose	Details
Individual Interviews	To explore teachers learning progress and provide opportunities for them to map out their learning	A total 12 interviews (*three interviews per teacher*) that ranged from 20-45 minutes
Classroom observations	To observe teachers' implementation of the pedagogies of SPS so we can collectively reflect on the process to identify their subjective approaches for implementing these pedagogies	20 observations notes and associated students' work samples (Five 35-minute lessons per teacher) that were researcher-observed and two that were peer-observed
Group meetings	To collectively plan lesson and reflect on the implemented lessons	Discussions, notes and audio recordings from 11 planning/reflecting meetings and two demonstration lessons
Teacher-led classroom-research	To empower teacher in this research and facilitate their exploration of implementing the pedagogies they are learning and identify its impact on the students	Four lessons (*one per teacher*).
Fieldwork journal notes	To aid reflexivity, I documented various activities and decisions made during the TPL activities and my associated thinking process	Throughout the fieldwork period and during initial data analysis.
Co-produced documents/resources	To supplement documenting the evolution of teachers' pedagogical praxis; to explore how these pedagogies are planned and implemented in the classroom and connect TPL with pedagogical development.	From the seven lessons we co-planned, lesson plans and students' worksheets were collected. Other documents we co-developed include two assessments and scheme of work for the term.

Individual interviews. To understand the nature, meaning, and significance of the social actions (Buetow, 2013) of pedagogical practice and professional learning, I decided to interview each teacher three times during our professional learning engagement. Individual interviews were employed in this research for two purposes.

Firstly, they were used to explore teachers' learning processes starting from the beginning, around the middle, and at the end of the professional learning activities. In particular, I wanted to gather data on how *pedagogy as **specified*** gets translated into *pedagogy as **enacted*** and ***pedagogy** as experienced* (see Section 2.2.3). Furthermore, I believed the impact of the professional learning activities on the above two dimensions of pedagogy and their relations could be probed using interviews. Secondly, the interviews were also used to set individual teachers' short -term professional learning goals and to follow-up on these goals. These interviews often were not associated with a lesson observation and so they were scheduled separately from the pre-post lesson observation interviews and discussions. The interview durations ranged from 20 to 30 minutes.

For the first and the last interviews, I used a semi-structured format (Appendix A.7). The first interview explored teachers' initial perceptions of their practices of teaching SPS and trajectories for the professional learning engagement. The second interview was less structured; I asked the teachers broadly '*tell me what you have learned and benefited from engaging in this inquiry*'. An unstructured approach to these interviews enabled me to explore the individualist nature of professional learning and pedagogical changes teachers were experiencing. Due to the individuality of the experiences at this stage of our professional learning engagement, I was flexible in the follow-up questions I asked (Cohen et al., 2007). These questions were based on the classroom observation and teachers' remarks in previous meetings. In this second interview, we also followed up on the goals set in the first interviews and revised the goals according to what the teachers felt were significant in their learning. This interview was also used to plan teachers' classroom-research lessons. The final interview focussed on teachers' reflections on how their pedagogies had changed over the course of the professional learning engagement.

Classroom observations. The purpose of this data collection method was to document the progressive adaptation and reflection on the science-investigation-based approach (SIBA) to teach SPS. Classroom observations allow researchers to directly experience the classroom environment and the various activities occurring within the classroom context first-hand (Fitzgerald, 2012). Such close engagement with the teachers enabled interactions regarding elements of their pedagogical practices that may otherwise seem invisible (Nind et al., 2016) and provided me with an additional lens into what the teachers do in classrooms to corroborate what they said in the interviews (Bryman, 2012). A major focus of this method was on documenting changes in *pedagogy as* ***enacted*** and *pedagogy as* ***experienced*** (discussed in Section 2.2.4).

The classroom observations were made both as a direct observer and a participant-observer. I had planned for the former, but in some of the lessons, the teacher either requested my participation by posing a question during the lesson or I felt I needed to interject on an explanation[36]. I justify such participation because the aim of this research or the data collection process is not to judge or evaluate teacher's practices but to collectively explore the pedagogical approaches and how they were working for these teachers in their classrooms. Thus, my participation in the lessons brought in elements of coaching and scaffolding, critical elements in social learning (Wenger, 1998) in TPL. Finally, participant observation was beneficial for this research because through such interactions in the classroom, I could gather unique insights into how teachers were interacting with the pedagogies (Fitzgerald, 2012).

For each teacher I observed all of the co-planned seven lessons. The observed lessons were preceded by an informal discussion on what the teacher was going to do in the lesson both in content and in SPS. The post-interviews were significant as they added immediate reflection on the lesson. Some of these reflection discussions were individual and informal while others occurred more formally and collectively in the group meetings. The choice of the mode of these reflections was mostly a practical choice as teachers were very busy and finding time for research-related tasks was difficult. In some of these lessons, I collected samples of student

[36] For example, when there were issues on laboratory safety the teacher forgot to mention or when some instructions about the investigation procedure were missed.

work to document how students' work was progressing and though these are not used as a direct data source, some of them have been used in the teacher narratives. Prompts used for these pre-post observations are in Appendix A.8.

For these observations, I went in knowing I was looking for (Borko, Jacobs, & Koellner, 2010; Gutierez, 2016): teachers' pedagogical approaches for SPS. Because I did not know how each teacher would enact the SPS pedagogies, I paid attention to the enactment of these pedagogies in the observations. I noted which skills were being emphasised and how these skills were defined, developed, and linked to the other SPS. These observation notes (apart from being a form of data itself) were also used for discussion with the teachers during their post-lesson reflections. In these lessons, with permission from the teachers, I also took photographs of students' work to aid analysis and/or our post-lesson discussions.

Group meetings. The group meetings utilised the school's scheduled fortnightly meetings and served two purposes for this study. Firstly, they served to plan the upcoming fortnight's science lessons. However, there were additional meetings we held to discuss and develop the teaching and learning resources. As we moved on with our professional learning activities and trialled out different iterations of the science-investigation-based approach and the associated resources, some of these meetings were used for reflecting on the implemented lessons as well. Additionally, we used these meetings to discuss administrative matters such as lesson observation schedules. To an extent these meetings took shape as focus-group meetings as we discussed specific topics of shared interests and experiences shared by the group (Powell & Single, 1996). Thus, in my records of these meetings, I was interested not only in the discussion itself but in the evolving interactions as well (McLafferty, 2004). Secondly, these meetings also provided an opportunity for teachers to experience the science-investigation based approach for SPS pedagogies through two demonstration lessons, that I conducted where the teachers acted as students. I documented my planning for these demonstration lessons and teachers' participation in the lessons. Details of these demonstration lessons as a feature of TPL activities are discussed in Chapter 6. In all these meetings, along with audio recordings, I also made extensive fieldwork notes, and in some meetings, with permission from the teachers, I photographed their work.

Teacher-led classroom-research. In order to make the TPL meaningful and empower teachers in their pedagogical praxis, it was imperative that the teachers take their pedagogical learning back into their classrooms, implement it, and observe students' reactions (Cochran-Smith & Lytle, 1990). For these reasons, each teacher was requested to conducted a classroom-based research assignment (Cochran-Smith & Lytle, 1993, 1999) as a sub-set of my research inquiry. Further, letting teachers conduct research into their classrooms honours these teachers for their 'grounded understanding of the schooling context to determine the questions that ought to be posed within their professional contexts' (Kincheloe, Mclaren, Steinberg, & Monzo, 2018, p. 427-428).

In a group meeting, the teachers were briefed on research approaches and data collection methods. We further discussed and planned the lesson which would be focussed on for teachers' research lesson. I observed all these lessons, making meticulous notes on teachers' SPS pedagogies. Following this, in individual meetings, we reviewed the data collected and reflected on their meaning for the teachers' SPS pedagogies, aided by my classroom-observation notes. All data collected from teacher-led-classroom research (such as the data that teachers collected from their students and the pre-post lesson discussions and reflections associated with planning and analysing the research-based-lessons) are documented as a combined data source and treated as such in the analysis and presentation of the findings. This is because this source of data is an event in itself that makes meaning in its entirety and breaking it into its individual components will detract from its purpose as a wholesome TPL activity, and the learning associated with it.

Fieldwork research journal. In order to aid reflexivity as a think-aloud method (Nind et al., 2016); in the research process, I maintained meticulous field-notes. These notes helped me to document my experiences and how my thinking both as a researcher and an educator evolved, questioning my predispositions and professional views of what and how SPS were taught and the scope and limits of teacher professional development in the Maldivian schools. These notes also enabled me to interrogate the dilemmas and inner conflicts I had with my conflicting identities on the insider-outsider continuum (Barrett, 2005; Eppley, 2006), supporting reflexive practices in this research process. Additionally, the fieldwork journal, which abounded with descriptive notes and reflective notes, provided a source to ensure trustworthiness in the research through establishing transparency as an audit trail (Ary et al., 2014; Shenton, 2004). Journaling helped me chronicle the process of data collection and the associated reflective accounts of my roles as professional development provider and researcher. I also kept a log of the different activities I was conducting with the teachers (see excerpt in Appendix A.9). Thus, through this form of documentation, I managed to document a comprehensive and reflective account of my both teachers' learning and my own learning in the research journey.

Co-produced documents/resources. In addition to these primary sources of data collection, as a secondary source of data, I also gathered our co-produced resources. One component of the professional learning was the co-development of teaching materials such as lesson plans, student worksheets, and teaching resources that aided in the enactment of science-investigation approach as a SPS pedagogy (Beyer & Davis, 2007; Voogt et al., 2015). We used the mandated science curriculum (syllabus) in developing these resources since teachers' familiarity to this document would help them in understanding these pedagogies and their application in their science teaching (Beyer, Delgado, Davis, & Krajcik, 2009).

Through discussions on drafting, implementing, and reflecting, we collectively developed lesson resources for seven lessons. These resources include lesson plans, a student's activity sheet (investigation template), and assessment activities. While the lesson plans were produced on the school's lesson plan template, the investigation template as the activity sheet was initiated by me. For each lesson, we modified the investigation template based on teachers' experiences of implementing it. The assessment activities were initiated by the teachers and, after discussing them in the group or individually with the science coordinator, we e-mailed or shared on Viber the revisions. Further, the school's scheme of work for the term was also modified for the explicit incorporation of SPS. A collection of these co-produced resources are in Appendices A.10 -A.12, as samplers of this data and the products of TPL.

Reflections on the overall process.

As the participative nature of this research depended on the investment and commitment of the participants as well as me as the inquirer, I decided to be present in the school daily. Overall, I aimed for 30 hours of contact time with each teacher for all the TPL activities associated with this study (Loucks-Horsley, Stiles, Mundry, Love, & Hewson, 2010). However, due to the nature of the activities, the contact hour allocation I had initially decided turned out to be an unrealistic under-estimate.

Prior to going into the field, I had to consider the nature of contact I would have with the teachers, because I was setting myself up for a prolonged fieldwork period which required teachers' engagement and commitment. Thus, I shared my contact details such as email and phone numbers. However, I did not take into consideration how critical this access was going to be for the actual professional learning engagement itself.

On the first meeting teachers requested that we make a Viber chat group to communicate. This was set up with the grade-level lead teacher (GLT) in it; she was there in a supportive yet in a monitoring role. This chat group was how I communicated collectively with the group for scheduling interviews and classroom observations. We were able to share resources such as our co-developed worksheets, assessment tasks, and links to further resources via this platform. Further, this online platform connected us virtually 24/7, a connection critical to the prolonged engagement I had with the teachers because it enabled flexibility in scheduling the professional learning activities. Such constant connection is acceptable within the Maldivian community and as a Maldivian I am familiar and used to this cultural norm.

Physically, I was frequently in the school throughout the school day during the fieldwork period. My presence in the school was supported by the school administration. I was there even when we did not have any meetings or data collection activities scheduled. I discovered that such constant 'hanging around' (Adam, 2015b) was valuable to understand teachers' school lives, the school culture and also the discourses amongst teachers. Most of these observations I made while 'hanging-out' with the teachers were recorded in the fieldwork diary and was used to refer to during conversations I had with the teachers. I would usually 'hang out' with the teachers when they would see off their students at the end of the school session. We would also have informal chit-chat about their teaching and the students (and parents). Interestingly, these were also the times where teachers were least stressed in their school day so I could use this opportunity for some reflective conversations on their teaching, the work we were doing and their overall ideas about teaching as a profession and what it meant to them. I also used this time to ask them to schedule our professional learning (and data collection) activities. I was always mindful not to be pushy with my research interests. However, being visible at this time of the day with the teachers made my presence in the school more public than I had planned for, but I understood that in the Maldivian school context, visibility is how one gets accepted into the school community. While I was with the teachers, some parents would recognise me; they knew I was collecting data for my PhD and some parent approached me, expressing their delight that I was working in their school. This is part and parcel of working in a small community that SIDS tend to have (Mcness et al., 2015; Moosa, 2013).

Data reduction and analysis.

As per my epistemological and methodological approach in this research I started data analysis during the data gathering process. Epistemologically, this was important to shape the pedagogies and the associated professional learning activities. Methodologically, this overlapping not only provided me with different types of data but richer and deeper insights (Maykut & Morehouse, 1994), making the initial analysis participatory and organic (Miles et al., 2014). The participatory nature of the analysis was in how each teacher both individually and collectively were involved in interpreting and meaning-making of the SPS pedagogies-based learning they were experiencing. Further, through negotiating aspects such as the scheduling of the data gathering events (classroom observations, group meetings etc.) teachers were leading and setting the trajectories for not only their professional learning, but how this study was evolving. Thus, at this stage, the participatory data analysis tended to be messy, complex, and even unpredictable (Seale, Nind, Tilley, & Chapman, 2015). The analysis was mostly directed towards understanding how teachers were experiencing the SPS pedagogies, identifying where and how each teacher's pedagogical praxis were evolving, and being aware of the tensions between teachers' learning requirements and the research. For example, when each teacher identified their TPL goals, I had to identify ways to support these goals. Also, based on incidents I observed and noted in classroom observations, I needed to re-orient our future TPL activities. Records of this process were made in my fieldwork journal as memos, amendments made to our schedules, or adjustments made to the TPL activities.

Post-fieldwork, the most significant analytical re-shaping I had to do on my data was to condense my data because over the course of six months I had managed to gather and produce a massive amount of data. The data was initially organised chronologically as the events transpired. However, in order to trace the teachers' professional learning journeys from the relevant data sources, for each individual teacher, and collectively trace the professional learning journey of the collaborative group, I needed to 'tease out' the individual teacher from the data to look at their journeys, while also looking at how the collective learning occurred. Such meaning-making required re-documenting to trace my own learning journey as researcher and learner, alongside that of my participants, because I too had lived on this landscape, shaping the professional learning experiences whilst being inherently shaped by it (Clandinin, 2006; Clandinin & Connelly, 2000). Such re-documentation (described below) enabled me to pay attention to the critical incidents, events, and utterances to capture 'eureka' moments, or flexing-point in the learning journeys, (such as when a new insight into SPS pedagogy was achieved), or to illustrate 'stuck points', intransigent obstacles that was hindering teacher's professional learning. As such, I employed narrative thematic analysis on this large corpus of data. I discuss below my application of narrative thematic analysis in this study.

Narrative thematic analysis.

Hyrvärinen (2008) claimed that narratives are, by nature, a prodigious genre because 'no definition will fit all narratives and that the desire for a conceptual consensus may be rather counter-productive' (p. 448). However, Clandinin (2013) pointed out that despite these contestations on definitions, all narrative inquirers seek to understand human experiences and the social contexts in which they transpire; and in this study it is teachers' professional learning experiences in exploring and learning SPS pedagogies within the context of primary schooling in the Maldives. This approach to analysis aligns well with this study's epistemological orientation: social constructivism (Shukla, Wilson, Lives, & Boddy, 2014) because as Riessman (2001) posited, narrative analysis 'does not assume objectivity but, instead, privileges positionality and subjectivity' (p. 696). Further these features are also important elements the participatory methodology adopted in this study.

For these reasons, I decided to first compose narrative stories for each teacher as a way to understand the holistic, temporal, spatial and socio-cultural meaning of the professional learning activities for each teacher within the context of their pedagogical practices for teaching SPS. I felt it was important to trace and analyse individual learning journeys as the object of analysis (Earthy & Cronin, 2008; Riessman, 2008; Shukla et al., 2014), but I paid attention to how each journey was unique and significant. Further, I believed it was important to consider these professional learning journey(s) in their entirety as a 'whole-story' rather than fragments or 'a slice of life'. The holistic nature of these stories can bring to the reader the individual, singular voices and experiences of the teachers together with the multi-voices and subjectivities of the group, paying attention to the critical events of professional learning that were created for this research purpose (Elliott, 2005; Riessman, 2008). Further, such stories are better than fragmented codes in capturing the uniqueness of these accounts of professional learning experiences as they preserves teachers' agency; they further provide coherence and the sequence for how these experiences unfolded and evolved (Adams, 2017; Riessman, 2000).

In composing the narratives, I paid attention to the significant learning event(s) for each teacher. Some of these were common for the four teachers while there were aspects unique to individual teachers. For example, '*Evidence from classroom-research*' was significant for all the teachers, yet each teacher's evidence and meaning from the evidence was different for their learning journeys. So, I selected this as a common aspect to present in all the narratives. On the other hand, the theme of '*Refocussing the purpose of TPL*' was significant to Dhalia because as a generalist teacher with no science background, her confidence in teaching science was low, yet the TPL activities made a positive impact on her science teaching. Similarly, as the science coordinator amongst these teachers and also with her stronger science background than her peers, Dheena often positioned herself in her learning through taking a leading role in the TPL activities and working more closely with me. Thus '*Leading the professional learning activities'* was a theme more apt to her learning journey. Table 5.6 provides as a sample, an overview of how these narratives were composed for Dheena. As such, the questions presented in the first column of the table was used to compose each narrative, yet the themes differed based on each teachers' subjective learning.

These narratives offered the first layer of analysis, enabling a glimpse into the individual learning of each teacher. Within these narratives, significant events, those' eureka' moments, and stuck points were highlighted to show the complexity and contextuality of these teachers' professional lives with regard to pedagogical praxis and professional learning. Whilst composing these narratives, I transcribed relevant parts of the audios of the individual interviews, meetings, and classroom teaching, and compiled other sources of data I had for the teacher under their narrative. In producing these narratives, the unit of analysis was the teacher (Adams, 2017; Arvanitis & Chryssi, 2015; Bamberg, 2012; Earthy & Cronin, 2008). In such narrative writing as data analysis, interpretation and analysis worked in tandem (Jeong-Hee Kim, 2016) because these two processes helped to develop an understanding of the meanings my participants gave to their learning. Such narrativising yielded lengthy stories for each teacher and was condensed to be presentable in this thesis (see Section 8.1). However, for member checking purposes, I shared the lengthy version with the respective teacher.

Table 5.6 How Dheena's narrative was composed.

Questions considered in compiling the narratives	Data sources used	Themes in narratives
What were my first impression of the teachers? Have I met them before, and if so how?	Background data collected and other information I had (e.g.: phase one data) First individual interview	**An initial overview**
How did the teacher engage in the TPL activities, learning and implementing the SIBA approach for SPS pedagogies?	Individual interviews Group meetings	**Leading the professional learning activities**
	Individual interviews Goal-setting notes Group meetings Co-developed resources Lesson observation notes and associated samples of students' work from the lessons Reflection discussions (individual and group)	**Taking control of professional learning**
How did the classroom-research go for the teacher? **What data was collected and how did the teacher engage with it?** **What was meaningful from this TPL activity?**	Classroom-research lesson (research planning discussion, research lesson observation, post-observation discussion, and teacher-collected data from the lesson)	**Evidencing from classroom-research (**A theme common to all teachers' narratives**)**
What are some long-term effects of this TPL engagement for teachers' SPS pedagogy?	Individual interviews	**Understanding pedagogies and flexibility in implementation**

For the second layer, I conducted analysis for content across these narratives (what was said and done) rather than form (how it is said) (Earthy & Cronin, 2008; Riessman, 2008; Vanassche & Kelchtermans, 2016). This analysis enabled me to search for themes of collective learning experiences of the teachers as a community. These themes were informed by theory (constructivist learning theory and social learning theory) and the conceptual framework for pedagogies discussed in Chapter 2, together with the findings from the Phase One of this study (presented in Chapter 6) to look for resonating patterns or themes (Clandinin, 2013). The themes were formulated to get a sense of the idiosyncrasies, nuances, and complexities (Birch, 2011), in (a) the teachers' professional learning within the contextual and systemic boundaries they work in; and (b) the evolution of their pedagogical praxis in teaching SPS.

For example, when analysing the narratives for themes in the second layer of analysis, I examined the level at which the teachers adopted the SIBA pedagogy and identified a continuum of practice associated with their past experiences. These practices were identified under the theme *Expanding pedagogic repertoire: Developing confidence* and was informed by TPL literature explored in Chapter 3, in particular how TPL is connected to developing teachers' pedagogical praxis. Similarly, across the narratives, I looked for professional learning activities that made a difference to teachers' learning or motivation towards using the SIBA pedagogy. This pattern-seeking was informed by the 'meaning/learning experience' component of the social learning theory discussed in Section 3.4, and the pattern in learning observed with the professional learning activity of teacher-led classroom-research. Thus, a theme labelled as *Students' response to teachers' developing pedagogical praxis: Science-investigation-based pedagogies made science fun*, was established (details provided in Section 8.1). Figure 5.4 provides a visual summary of the overall narrative thematic analysis process, as applied in this study.

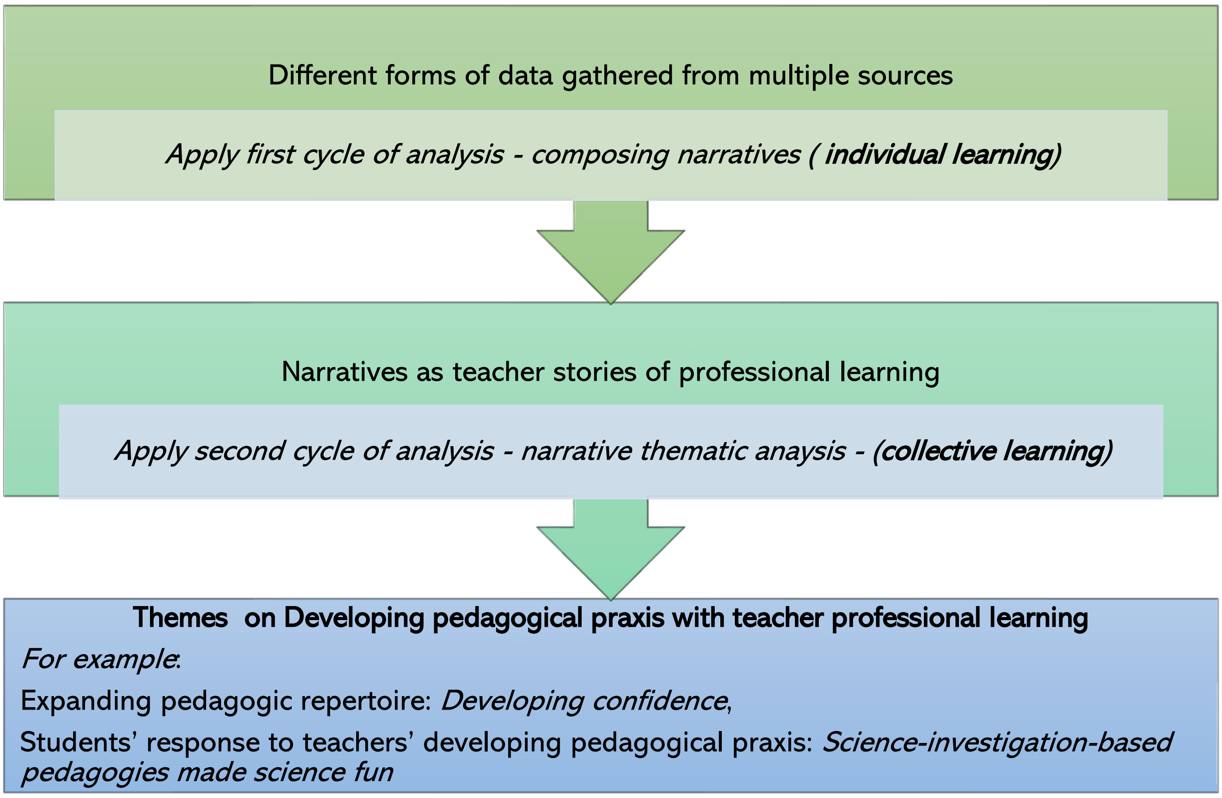

Figure 5.4 The two layers of narrative analysis as applied in this research

5.2.3 Translation and data sources indicators

In this study, there were different forms of **oral data** (for example: face-to-face interviews, group interviews and discussions), **written data** (for example: lesson observation notes, reflection notes) and **products of work** (for example: worksheets, lesson plans) gathered. In the oral data, such as from the interviews, we conversed primarily in Divehi, but with plenty of code switching between Divehi and English, both from my side and the participants'. Halai (2007) observed that when local insiders conduct research with science teachers, such code-switching is common. Further, similar to what Halai had observed in her research with Pakistani teachers, code switching in my research occurred in three ways: namely, certain scientific terminologies do not have an equivalent Divehi term[37]; common words in the teaching profession are communicated in English[38]; and certain English words have become part of the Divehi vocabulary[39]. Acknowledging this code-switching is critical to this research because these expressions were a significant part of the conversation that made sense within the dialogue, but in translating these conversations to English, words/phrases may be awkward in a sentence, potentially affecting how I (re)present these teachers' voices and professionalism (Halai, 2006; Halai, 2007). Thus, in some instances (mostly in Chapter 8) where I use quotes from the interview data, I first provide the Divehi version followed by an English version. However, I acknowledge that this English version is not a direct translation because they have undergone few transliterations and transformations to produce 'transmuted texts' (Halai, 2007; Sriprakash, 2012), that read well for the English reader.

The written data (such as my fieldwork journal entries, lesson plans, observation notes, samples of students' work) were in English and so they are presented as is; I have added some explanatory notes and analytical thoughts where relevant. All Divehi words/phrases/terms I use are presented in italics, to distinguish it from English terms.

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[37] For example, words such as 'investigation', 'surface-tension', 'photosynthesis' are science-specific vocabulary and oftentimes do not have an equivalent term in Divehi. Even in instances where there may be an equivalent Divehi term (Divehi word for prediction/hypothesizing is *lafaakurun,* but is not preferred)

[38] For example, words such as 'understand', 'curriculum', 'teaching', 'sequence', 'experiment' were in English despite there are equivalent Divehi terms for it

[39] For example, words such as 'school', 'text-book', 'classroom', 'laboratory' have been assimilated into part of the Divehi vocabulary.

Section 5.3 Conducting a trustworthy research process

In this section I discuss the various issues pertinent to managing and conducting a trustworthy and rigorous inquiry. I first explain my positionality as an insider-outsider and describe some of the dilemmas I faced in negotiating this positionality. As such, I explain how I practiced reciprocity and reflexivity to ensure transparency and rigour in the research process. Next, I explain how I maintained quality in this research through attending to various elements of trustworthiness in qualitative research. Finally, I explain how I addressed matters on both procedural and relational ethics in the research process.

5.3.1 Positionality, reciprocity and reflexivity

Insiderness and outsiderness have been viewed as two mutually exclusive domains of researcher positionality (Labaree, 2002). Thus, at the planning stage of this study I naively assumed that my position in this research was as an insider since, being a Maldivian, I was conducting research with people from my community and my same profession; so we would have a shared cultural past, (Innes, 2009; Labaree, 2002) as science educators in the Maldives. Additionally, I was familiar with the participants either as my colleagues or as my students whom I had taught in pre-service. So, I relied on this familiarity to make me an insider, enabling participants' instant trust, and the ease of access to the information I was seeking.

However, in the field I, realised that the virtue of shared membership in the researched community would not guarantee me insider status (Innes, 2009). Conducting research in a situation where familiarity with the community made me an insider (DeLyser, 2007; Griffith, 1998; Innes, 2009; Kanuha, 2000; Labaree, 2002; West, Stewart, Foster, & Usher, 2013), but the power-imbalance of me being a researcher associated with my reputation (Labaree, 2002; Mcness et al., 2015; Milligan, 2016; West et al., 2013) as a teacher educator and curriculum developer made me an outsider. Despite my attempts to curb my 'expert' identity, participants would refer to me as '*Miss',* a formal mode of communication in Divehi[40], demonstrated this authority and the associated power they ascribed to me. Thus, I realised the insider-research position is far more complex, messy (Chavez, 2008), and fraught with moments of identity-clashes, and this needed more reflexivity (Mcness et al., 2015).

Retrospectively, my position in this research was an ''inbetweener' researcher, neither entirely inside nor outside' (Milligan, 2016, p. 235). This positioning was also flexible and fluid on the insider-outsider spectrum, determined by the nature and temporality of my interactions with my participants, or simply by their 'gaze' on me (Barrett, 2005; Chavez, 2008; Eppley, 2006; Hall, 1997; West et al., 2013). For this reason, Labaree's (2002) extended and restructured view on the insider-outsider continuum into a three-dimensional concept, where the *x*-axis maps the insiderness, *y*-axis maps the outsiderness, and *z*-axis maps the temporality of the interactions was useful for me. In Phase Two, my insiderness intensified with more time I spent in the field and the trust in me by the participants developed. However, during our group discussions and when teachers sought me as a problem-solver and guide[41], their views of me as an insider diminishes while intensifying my outsiderness. Further, these dynamics also changed as teachers became more comfortable with the science-investigation-based approach to teach SPS. Thus, I experienced insider-outsider as multi-dimensional that was constantly in flux and

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[40] In *Divehi* language, there are three degrees of communication associated with a honorific system, representative of the social castes. The differences are in the variant of the word you use to refer to the person in dialogue, acknowledging their social status; the highest degree is often used to refer to religious deities; second level is for people you respect and treat as above you in social stratification (for example, government officials, revered scholars, etc.); and the lowest level you often use for communicating with friends/colleagues (Kulikov, 2014). In this instance the participants used second level of communication with me.

[41] For example, when they requested me to participate in the classroom teaching by co-teaching.

negotiated by the very nature of the meaning we were creating through our interactions.

Such positionality matters were obvious and manifested through the relationships I had with my participants. Further, I also experienced internal dilemmas around my multiple roles: professional development/learning provider facilitating these activities, co-researcher, trying to work *together* with the teachers, and the researcher organising and collecting data for the study, making this identity negotiation complex and often times messy. While each of these identities required a different positionality from me, often these identities manifested in combination and extracting any single identity from the situation was impossible. Consequently, my positionality in this research vacillated between insider-outsider, on a spectrum and in a process of ongoing evaluation and negotiation. Acknowledging these positionalities is important because it creates transparency to the research process making me aware of how and why I was making certain decisions. There are two major ways in which these positionalities were acknowledged; **reciprocity,** which focussed on my actions during the fieldwork, and **reflexivity,** the significant post-fieldwork that I engaged in, especially around how I analyse and report the findings from this study.

Reciprocity is a critical feature inherent in the design of this study because the epistemological and methodological orientations value the relationships and the rapport between researcher and researched (Mertens, 2015). As discussed above, my insider-status as a science teacher educator and curriculum developer imbued me with some power and authority. This power imbalance manifested in teachers' reactions to some of my interview questions regarding the science curriculum, and where teachers were uncomfortable in answering or gave me a text-book answer. McKenney and Reeves (2012) explained that often in social research, such a desire for the participants to provide information that they believe the researcher is seeking can be due to a power-imbalance between the researcher and the participants. Similarly, when interviewing with my colleagues, I assumed we could talk freely, but such free talk also brought in a dilemma for me. Being an insider and with access to certain knowledge and discourse made me felt I was holding some confidential and privileged information (Coar & Sim, 2006). I tried to reduce this imbalance by explaining to all participants that my researcher role is not about judging nor evaluating their practices but trying to understand them. As such, I offered some of the teachers a professional development workshop (outside the scope of this study), and for my colleagues I offered my feedback on some of the teaching resources they were developing.

My relationship with the participants in Phase Two data collection was complex. These relationships were strengthened through my participation in various (professional and social) activities at the school where I felt and was referred to as 'one of us'. For example, from a professional perspective, I accepted the school's request to be on the judging panel for their school-wide science exhibition, and from a social perspective, I joined teachers in various school-level celebrations such as Children's Day festivities and teachers' activities to mark the school anniversary. The more such reciprocity I offered, I felt teachers' acceptance of me as a researcher strengthened. There were also other ways in which I provided reciprocity to my participants. Through the participatory nature of this phase of data collection, participants were not only developing their pedagogies, but also enhancing the research skills they were learning in their postgraduate studies. Further, I was a coach or mentor providing teachers with possible resources, advising them based on my experience, networking them with my TE and CD colleagues, and often functioning as a passionate researcher (Guba & Lincoln, 1994) and friend, listening to their personal and professional dilemmas.

Reiss (2005) cautioned when reporting research, especially by one individual, that there is an unintentional tendency to report findings in a way that may marginalise or misrepresent those with different perspectives. To minimise such misrepresentations in this study, multiple sources of data collection were employed, thereby enabling me to bring participant-driven data and teachers' voice to the forefront of this study (Milligan, 2016)[42]. Such practices were part of my reflexive practice, complementing the ontological and epistemological framing of this study.

Finlay (2002) defined **reflexivity** as 'thoughtful, conscious self-awareness' (p. 532). Peshkin (1988) expanded this further, explaining that reflexivity from an angle of subjectivity is about explicitly being aware of how the researcher's personal attributes distinctively filter, interpret and coalesce the data into a unique contribution to the inquiry. Reflexivity required me to interrogate my conflicting roles and identities and understand the direction of my actions. For example, in my professional provider identity, I was uncomfortable and frustrated when the professional learning activities did not go as planned, but my researcher identity enabled me to seek the opportunities (for the professional learning activities and the research trajectory) from such unpredictabilities and use 'reflexivities of discomfort as a guide' (Thomas & Vavrus, 2019 p. 13). I had written in my fieldwork journal:

> Teachers are overworking with multiple commitments within the school plus other commitments (study, family, health). This leads to **no/less incentive to work on my professional development/learning engagements**. Working on PD as this simply becomes a mere admin matter (as they do it because it is a Ministry imposed policy imperative) … a 'forced' matter for teachers. Leading Teacher tries to implement this engagement for my research but there is not much engagement (they don't bite!). This is evident in how the grouping did not come from the teachers, they did not ask what it is for, how it can be done and what we are trying to achieve. So, teachers imply and passively agreed to how they are grouped. Where is their voice?
>
> (Research Journal, 20 February 2018)

During analysis, because of this reflexive writing, I was able to explore elements of 'teacher passivity' and 'differing meaning on collaboration' across the dataset. Further, these writings also revealed to me, some of my prejudices on teachers.

[42] For example, in Chapter 8, I have used teachers' interview quotes primarily in the language we had communicated in, Divehi. For accessibility to English readers, I have also included a translated version of these, but I stand that these translations may not truly (re)present these communications we had.

Throughout the process of data analysis in this research, I also engaged in reflexive conversations with my colleagues, supervisors and other academics through conference presentations. These conversations enabled me to reflect on some of my biases and assumptions of holding ‘privileged and powerful knowledge’ position (Thomas & Vavrus, 2019). For example, I was not aware of the value of multiple forms of pedagogies that was reflected in my data. During a conference presentation a presenter provided me some feedback that changed the trajectory of my data analysis.

Finally, I practiced ethical reflexivity (Guillemin & Gillam, 2004) associated with negotiating my positionality. I was one of them, a middle-aged woman, wearing hijab, conversing in Divehi, using the terminologies that teachers use. I used these feature to gain teachers’ acceptance of me into their community, to gain their trust as an insider, and yet I was mindful not to make assumptions about their school practices nor their personal lives. I would assume an outsider positionality and inquiry about certain school-specific practices but used my insider-knowledge of the Maldivian culture and practices to unpack and understand such school-specific experiences. I was conscious of how I negotiated such positionalities and I worked to be reflexive of my actions and decisions: how they impacted the data analysis process and how I report the findings.

5.3.2 Research trustworthiness

Nowell, Norris, White, and Moules (2017) explained that in qualitative research, quality and rigour are established through the steps we take to ensure the ‘trustworthiness’ of the research. Such trustworthiness is about asking the question ‘how can an inquirer persuade his or her audience (including self) that the findings of the inquiry are worth paying attention to’ (Lincoln & Guba, 1985 p. 290). Further, it is about rendering transparent the process by which the interpretation(s) of the data comes about (Riessman, 2008). In this section, I discuss how I managed research trustworthiness through credibility and transferability.

Credibility.

According to Shenton (2004), credibility, an essential feature in establishing research trustworthiness, is about how congruent the findings are in reflecting the participants' realities. The methods I employed to gather the data and interpret realities of teachers' professional learning and pedagogical praxis considered credibility in several ways. Firstly, the familiarity I have with my participants in both Phase One and Phase Two was critical (Shenton, 2004). Such familiarity together with the long-term engagement in Phase Two enabled me to gather rich and thick descriptions of how teachers' SPS pedagogies operate and how they evolved through the professional learning activities in a manner that is showing rather than telling (Tracy, 2010). Secondly, throughout the whole research process, I maintained a research diary that was used as a 'reflective commentary' (Shenton, 2004) as an 'audit-trail' for my decisions, thinking and the evolution to provide transparency in this study.

Thirdly, member-checks or member reflections (Tracy, 2010) allowed me to see if the findings I have produced are a 'recognizable reality' in the views of my participants (Maykut & Morehouse, 1994). In Phase One, I offered the participant the choice of either sharing with them a summary of the interview points we discussed or sharing the interview transcripts. All participants requested for the former and most of them agreed to the summary with a few adding clarifications points around their feelings with the new curriculum. In Phase Two, for member-checking purposes I shared the narratives I composed for each of the participants. They all responded positively to this, and no alterations nor modifications were requested, one of the teachers even complimented me on how well I had captured their learning process. Lastly, the research design of a sequential study was advantageous in ensuring the credibility. As the results of Phase One informed Phase Two, and as half of the participants of Phase Two were in Phase One, there was an established credibility to the data collection/generation methods, and the research itself.

Transferability and relatability.

Transferability refers to the generalisability of the research (Nowell et al., 2017) or the relatability of research to other contexts. In qualitative research, transferability is achieved when readers can resonate with the research so that they can transfer or extrapolate the findings of this research to their contexts or sites (Lincoln & Guba, 1985; Shenton, 2004; Tracy, 2010), such as schools or educational systems. To facilitate such transferability as relatability, I have provided comprehensive contextual information (starting from delineating the context in Chapter 4), detailed description of the research process (Part Two in this chapter), and how I maintained reflexivity throughout research process (discussed in Section 5. 4.1).

5.3.3 Ethical considerations

Bogdan and Biklen (2007) wittily reflected on conceptualising ethics: ‘like the words *sex* and *snake*, *ethics* is emotionally charged and surrounded with evocative and hidden meanings’ (p. 48, emphasis theirs). Ethics is a sensitive yet important ground that a researcher needs to be clear and explicit about, both for the integrity of the research and for the welfare of participants and the researcher. Thus, in this section, I discuss how I followed procedural institutional ethics and offer my personal relational and situational ethics in conducting this study.

Access to participants and informed consent.

I was aware that my insider position of the researching community could provide me direct access to the participants. However, such access is neither ethical nor respectful to my participants. The data collection process started after obtaining ethical approval from the School of Education (SoE) ethics committee (see Appendix A.2 for the approval letter). Next, I sought formal permission from the Ministry of Education of the Maldives so that I could access the schools. Following this approval (see Appendix A.3), I emailed all the targeted schools explaining my research and the participation I was seeking from them. Once the schools for Phase One were established, I approached my potential participants through telephone to establish contact and interest, and e-mailed them the information letters and consent forms (Appendix A.4).

For Phase Two, because of the nature of the data sought, I needed closer interactions with my participants, and so I requested school permission face-to-face. Due to the nature of data collection/generation in this phase, apart from sharing the information about the research (see Appendix A.5), I requested teacher participation via the researcher-co-researcher contracts (Appendix A.6). Having a contract as informed consent enabled me to continuously negotiate and re-negotiate the purposes and expectations as the research proceeded (Clandinin & Connelly, 2000). Such negotiations in this phase was also important because of its longitudinal nature: I was asking the teachers for a long-term commitment to this research, yet I wanted that commitment to be flexible, voluntary, and managed by the teachers' need for professional learning, rather than doing me a 'favour'. The research contract laid out our roles of teachers-as-co-researchers and me-as-researcher. This way, there is transparency of roles and expectations, and teachers as co-researchers are empowered (Erickson, 1998) and were open for constant negotiation[43]. I was also respectful to minimise disruption to the participants' daily teaching practices as a result of their participation in my research (Cohen et al., 2007). For this reason, most of the data gathering activities were embedded into teachers' daily routines in the school. Unavoidable disruptions were negotiated by proposing solutions to the stakeholders (school principals and leading teachers) which functioned as researcher reciprocity[44].

During data collection in Phase Two, I faced several situational ethical dilemmas associated with 'informed consent'. On one instance, the leading teacher (LT) sat in with me for my classroom observations for Dhasya and requested I write a formal evaluation of Dhasya from an independent point of view. The backdrop to this was that the LT was documenting evidence on Dhasya to request her to do some further training to improve her teaching skills. This request posed an ethical dilemma because, while I wanted to be professional with the LT, I could not 'evaluate'

[43] For example, the scheduling of the activities, the direction of teacher-led classroom-research was completely teachers' choice.

[44] For example, I offered support to the school during their 'curriculum thematizing' exercise, see section 8.3.2.

a participant without her permission to do so. I was there in Dhasya's classroom for only what she had consented to, to be in my research, so despite what her LT requested, I decided it was not ethical to follow the request.

Another example was in an instance where I had planned for a 30-minute discussion with Dhalia, scheduled for 1:00 pm in the school staffroom. Dhalia came to the meeting sweating profusely and out of breath. She explained that after she had sent her students off, she dropped her eldest daughter home[45] and brought her younger daughter to school. Though she lived a fifteen minutes' walk away from the school, being outside in the midday heat and humidity of a typical Maldivian sunny day[46] had clearly drained her energy. We started the meeting with this burnt-out start; 10 minutes into the discussion Dhalia put her head on the table and to me it was clear she was exhausted and asking her to reflect on her practice whilst she could hardly breathe was not ethical. Despite the fact she came to the meeting wanting to 'help my research', I decided to stop the discussion for the day. It was common to have instances where teachers were physically present for the research related activities but they were unable to contribute actively and constructively.

Anonymity & confidentiality.

The essence of ethical research is that the information provided by participants should in no way reveal their identity (Cohen et al., 2007) in a way that could harm them. In Phase One, with the teachers this was not a significant issue. Although the schools were aware of their participation, because their identities are anonymised in presenting the findings, it should not be easy to trace their original identities. However, with my colleagues (teacher educators and curriculum developers) and because we conducted focus group interviews (for each group separately),

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[45] Bothe her daughters attends this same school. Eldest was in morning session and youngest was in afternoon session

[46] Approx. 32 degrees Celsius.

members in focus group were familiar to each other and aware of the conversations they were part of. In the Maldives, there are only three science curriculum developers and in the MNU, there are only a few science teacher educators. Anyone who is familiar with the education context in the Maldives can potentially discern who these participants are despite my use of pseudonyms for them. However, it may not be easy to trace their quotes outside of the circle of participants. This was the limit of confidentiality available for me because of the small community I was working with and could not be avoided in the context of this research. Writing up the research involved the constant practice of ethical mindfulness as I constantly checked to ensure that I have not presented any information in this thesis that I believe could harm my colleagues.

In Phase Two, due to its participatory nature and small number of participants, maintaining anonymity was difficult because I found that 'confidentiality and anonymity are difficult to achieve and counter to the purpose of research' (Halai, 2006 p. 4); because I needed teachers to work together and in collaboration, thereby it was impossible to maintain anonymity among the participants. However, some anonymity was established especially in the reporting of the findings by the use of pseudonyms for the participants in both phases. This difficulty in anonymity was significant in the Phase Two due to the epistemological approach to participatory research which relies on data from collective work.

Further, due to the small number of participants in Phase Two and the transparent nature of the Maldivian community, it is likely that the participants and other stakeholders may be aware of their participation in my research (Moosa, 2013). The descriptive accounts of the school and the teachers can expose their identities because my involvement with them during the prolonged fieldwork was visible in our tight-knit, small community and the social circles we moved in. This is an ever-present dilemma in studies conducted in small communities in SIDS (Moosa, 2013). In such instances, Halai (2006) advised use of ethical practices that foster building relationships of trust and mutual respect with the participants in such a way that information can be shared without risk of harm to those concerned. I subscribed to practices in the development and sharing of the resources (example, lesson plans, worksheets, and resource materials) that were developed through the research activities. I communicated these intentions with my participants at the beginning, and the teachers expressed that they would prefer that materials we co-produced to reflect the school as the owner, but where I have used these documents in this thesis, I have removed the school logo to maintain anonymity.

Conclusion

This chapter has set out the research methodology for this study. I have framed this study by declaring that reality and knowledge of SPS pedagogies and TPL are subjective and co-constructed by the social actors. This mindset has informed this study's methodology as a sequential participatory study involving two phases of data gathering/collection.

The purpose of the Phase One was identify to the status quo on SPS pedagogies and TPL in primary science education in the Maldives. This was achieved through interviews with primary school teachers, teacher educators, and curriculum developers. This data was analysed to inform the development of TPL activities that were implemented as Phase Two of this study. These findings are presented in Chapters 6 and 7. The purpose of Phase Two was to map generalist primary teachers' professional learning and associated pedagogical praxis through professional learning engagement. Further, as discussed in this chapter, because of the nature of Phase Two, I was able to engage with my participants over a prolonged period to gather data from multiple sources. These data were first re(created) into narratives and further analysed across narratives to explore similarities and differences in practice of SPS pedagogies and teacher professional development and learning.

Lastly, in this chapter, I have discussed how I managed the research process, especially the dilemmas associated with researching with a community I identify with but of which I may not be an 'accepted' member. These dilemmas posed both epistemic and methodological issues in this research, and I have discussed here how I managed them through the process of reflexivity and adherence to mindful ethical practices.

Chapter 6. The Status Quo

How a teacher thinks about his/her practice is underpinned by a combination or system of beliefs that guides classroom instruction.

(Hoban, 2003, p. 20)

Introduction

The purpose of this chapter is to present findings from Phase One which are pertinent to answering Research Question 1, namely:

RQ1: How do primary teachers in the Maldives conceptualise and support their students to develop science process skills and its pedagogies?

Phase One was designed to identify the 'status quo' around science process skills (SPS) pedagogies and teacher professional learning (TPL) in primary science education in the Maldives. Section 6.1 begins with presentation of findings pertinent to understanding how teachers conceptualise SPS pedagogies. In particular, I present content on the dispositions of teachers, teacher educators, and curriculum developers towards SPS pedagogies in science curriculum documents and in practice. Section 6.2 presents findings to inform the design of the bespoke Phase Two professional learning activities. Section 6.3 integrates the findings from the previous two sections to inform the features of the teacher professional learning experience that was developed as a collaborative pedagogical inquiry.

Section 6.1 Conceptualising science process skills pedagogies

In this section, three themes from the findings are presented: discourses on SPS pedagogy, the science curriculum and teachers, and the SPS pedagogies practiced. The first theme (discourses on SPS pedagogy) was identified through the data analysis process while the latter two themes were informed by the conceptual map of the dimensions of pedagogies provided in Section 2.2.3.

6.1.1 Discourses on SPS pedagogy

As discussed in Chapter 2, one reason why it is important to understand how teachers view SPS is because teachers' conceptualisations of these skills determine how they employ them in their pedagogies. Teachers' views of SPS and associated pedagogical practices are presented in this section, including responses from novice teachers (NT), teachers with more than five years' experience (ET), and teachers who are science coordinators (CT). These views are contrasted with teacher educators (TE) and curriculum developers (CD) to highlight the variation between these three group discourses.

Defining science process skills.

Most of the teachers interviewed in Phase One **demonstrated a limited understanding of the range and variety of science process skills (SPS).** These teachers are all generalist teachers and not specialised as science teachers, with the exception of the leading teachers (LTs). Teachers initially identified the SPS as observing, classifying, and measuring – the basic science process skills. Aneega (ET), for example, expressed her philosophy of teaching science as providing students' opportunities to observe and classify.

With further prompting, eight of the teachers expanded their list of skills to include advanced process skills such as hypothesising, analysing, and inferring. A few of these teachers identified investigation as a single skill, as opposed to considering it a combination of all the individual SPS (as discussed in Chapter 2). These limiting views impacted teachers' SPS pedagogies; implications for this are presented in Sections 6.2.2 and 6.2.3.

Defining SPS pedagogy.

All of the teachers interviewed agreed that SPS are important in teaching science, especially at the primary grades. Upon inviting teachers to share with me a lesson where they had taught SPS, their follow-up question provided insights into their conceptualisation of SPS pedagogies. Enaz (ET) clarified whether or not I was looking for a

> Lesson where the students explore and find things on their own?
>
> (Translated Enaz Individual Interview, 5 August 2017)

Bathool's (LT) expression was similar, but she added an element of students' independent learning to her definition. Such dispositions **demonstrate teachers' views of SPS as a teaching approach where students independently and actively engage in the learning activity.**

Faheema (CT) had a broader view:

> Oh, we did our first investigation... Last year students did experiments where we focussed on recording, so now it is investigation we are doing
>
> (Translated Faheema Individual Interview, 5 August 2017)

This quote is interesting because her pedagogical approach to teaching SPS (experimenting, recording, and investigating) can be interpreted as an understanding of the development of the individual skills to build towards the combined investigations skills. This knowledge can be attributed to the fact she is considered as a science specialist. However, on further discussion about the investigation lesson (in Section 6.2.3), her students' work samples did not demonstrate such an explicit integration of SPS. Faheema and teachers like her perhaps subscribe to such pedagogical practices because her background has developed her understanding of the nature of these SPS as a progressive development of these skills from basic towards integrated skills and finally the combined investigation (as was discussed in Section 2.2.3). Thus, broader **views of SPS can be related to teacher's**

specialism, where those teachers who have specialised in teaching science can better articulate and apply these skills in practice.

An interesting finding is the **'regurgitation of theory' talk** present in some of the interviews**.** To illustrate, Enaz (NT), eloquently expressed the importance of observations skills, focussing her discussion on hypothetical lessons:

> observing is very important….we need to let students do this repeatedly, most of the time students don't evet know *microscopeyga loa jassaalan ves* [use a microscope]..but when students observe like this they will remember,...how to use the equipment,… remember what they learnt about the beach rocks [from a field trip]
>
> (Translated Enaz Individual Interview, 10 August 2017)

Similarly, Angeega (ET) when explaining her lesson, she used terms such as 'inquiry-learning', 'discovery-learning' and 'inductive-learning'. While these are ideal constructive pedagogies for science (as discussed in Chapter 2), upon analysing her students' work-samples, there seemed to be a gap between these theoretical principles and how these pedagogies were implemented in her teaching. Such 'regurgitation of theory' was prevalent in how some of the teachers described their practice in lieu of their ideal lesson/teaching.

Teachers employed **different styles of teaching activities** within their pedagogical approaches. The most common activities were field trips, teacher-led demonstrations, guided investigations, and experiments organised either as whole-class activities or group-activities**.** This range of activities has roots in constructivist pedagogies, but limited conceptualisations and awareness of the SPS and the pedagogical opportunities these activities can offer tends to limit how teachers enact these activities.

Teacher educator (TE) and curriculum developer (CD) views on teacher practice.

Both groups (TEs and CDs) highlighted teachers' understanding and limited pedagogical practices of SPS. Both groups pointed out that this limitation exists because teachers did not seem to fully comprehend the range of science process skills, demonstrating a **strong deficit view of teachers.** The TEs demonstrated this:

Kamana: I have not seen ever a lesson where more than three of these process skills have been addressed. Even if the topic is ideal for it, the curriculum says it, it just does not happen.

Jeela: With skills, they [teachers] always do observations. That is where it begins and that is where it ends. Always observation. No prediction or other skills. Very rarely there may be making a conclusion based on the observations.

Kamana: Even if observations are done it is very guided. Do not give student an open-ended observation task to freely observe, the teacher tells them what to observe and even to the point what to expect in the observation.

(Translated Teacher Educators Group Interview, 6 August 2017)

These statements are emblematic of TEs' deficit views on teachers, one that was also shared by the curriculum developers (CDs). But both groups also identified various systemic issues that could potentially impact teachers' practice, including limited classroom time, unavailability of resources, and differential parental expectations. Mina (CD) pointed out that both pre-service and in-service teacher development was insufficient, demonstrating her acknowledgment of the poor support offered for teachers within the system. Such an understanding can also signify that CDs may not always view teachers as deficit:

> I personally feel one reason for this is the pre-service training being inadequate and unless it changes to accommodate these curricular changes, we cannot see this shift in the schools. This methodology has to be practiced in their pre-service, see it practise it and then do it. They can learn from psychology and theory that this is the idea way to do it. But that is not enough to change practice… They need to observe a classroom themselves and then reflect on teaching happening in these classrooms, and then make that change.
>
> I also feel in-service training is a major issue. This is not targeted and geared to teaching science. When there is no in-service training given to teachers on these new approaches and when pre-service is insufficient, I question how we are actually supporting the teachers.

(Translated Curriculum Developers Group Interview 7 August 2017)

Despite Mina's views, most TEs and CDs approach teachers from a deficit model; the support these groups offer to the teachers as part of the science education community is limited and thus maintains the status quo of teaching practices as conceptually and procedurally limiting.

In summary, the discourses on SPS pedagogies are diverse but limited among teachers. Teachers' limited understanding and application of SPS can be attributed to limited conceptual understanding of the skills, echoing what other researchers have highlighted (for example, Ambross, Meiring, & Blignaut, 2014; Rauf, Rasul, Mansor, Othman, & Lyndon, 2013; Roberts, 1988; Shahali, Halim, Treagust, Won, & Chandrasegaran, 2017). Further, teachers seemed to be aware of the active-learning nature of SPS, employing various teaching and learning activities rooted in traditions of constructivist pedagogies; however, there seems to be a multitude of factors that hinder teachers' conceptual and procedural understanding of SPS and associated pedagogies. These factors are presented next.

6.1.2 The science curriculum and teachers

In Section 4.4.2, the science curriculum/syllabus structure and its expected pedagogies (progressive constructivist active learning pedagogies) were explained. In particular, the Working Scientifically strand was identified as the component of the curriculum that prescribes the different SPS and associated pedagogies. In this section, I present findings pertinent to teachers' understanding and interpretation of these curriculum prescriptions for their classrooms.

Terminologies and language.

The terms used in the curriculum such as 'strands', 'outcomes', 'indicators', and 'competencies' are OBE terminology that most teachers were not familiar with. None of the teachers could articulate the structure and sequence of the science curriculum, at least not as I assumed, they would. This was disappointing for me because (from my teacher educator and curriculum developer 'ivory-tower') I had previously believed teachers would have such an awareness. At this point in the interviews, I shared the science curriculum documents with the teachers as a way of explaining the connection between the curriculum, their practice, and the purpose of my study. When I directed them to the Working Scientifically strand, some teachers stated that ‘yes, I have seen it’ or ‘Oh, you mean this one… I see’. Faheema (ET) pointed out that lack of interpreting guidance provided by the curriculum:

> We have issues with the curriculum. A topic and outcome sometimes are not clear. We do not know the depth to go and it’s not clear. With experience we may get this …But in coordination meeting we do discuss level, but mostly we are not sure it of the depth
>
> (Translated Faheema Individual Interview, 6 August 2017)

Such comments demonstrate two things regarding teachers’ (un)familiarity with the curriculum, taking into consideration the recency of the introduction of the curriculum. Firstly, the **language and terminologies used in the curriculum was not popular amongst teachers.** Secondly, this barrier in understanding the language and terminology in the curriculum could potentially **bring in difficulties in understanding, interpreting, and enacting** the science curriculum/syllabus. These matters are exacerbated by the teachers’ generalist teaching backgrounds.

Teacher educators (TEs) seem to be aware of these complexities involved in interpreting the prescribed curriculum. Ifham expressed:

> There are all these levels in the curriculum, the outcomes, indicators, and then success criteria...on top of the key-competences of the curriculum. All these jargons teachers are now bombarded with, that they don’t understand and yet have to implement in the classroom.
>
> (Translated Teacher Educators Group Interview 6 August 2017)

Kamana (TE) added that the issue of translating and interpreting a curriculum written in teachers’ second language adds another layer of complexity in interpreting the curriculum:

> There is also the issue of language competency. Teachers’ understanding of the terms use in the curriculum often gets interpreted wrong or incorrect by teachers…a matter of translation errors. Then in the actual instruction of the skills too there are issues… to do with being incompetent in the language of delivery
>
> (Translated Teacher Educators Group Interview, 6 August 2017)

The result of all these complexities in interpreting the curriculum, together with the novelty of the curriculum itself, tends to obfuscate teachers' attempts to interpret and translate the curriculum prescriptions into practice.

Familiarity and confidence in teaching science.

The level of familiarity and understanding of the overall curricular requirements varied considerably among the teachers. Faheema (ET) stated that because of her passion for biology, she enjoys teaching the topics in the strand of *Life and Living* and prefers to spend more time on this strand, resulting in her stronger familiarity with this strand than the other strands. Conversely, Diana (NT) expressed that her lack of science content knowledge made the science curriculum document and the syllabus difficult to interpret, so she preferred using the textbook as her guide. The textbooks she referenced were developed for the implementation of this new curriculum. For Heena (ET), familiarity with the curriculum was increasing with time:

> last year we could not cover the curriculum because it was much later in the year when we reached the Working Scientifically strand, so just did two experiments, but by then the year was over …but this year it is different

(Translated Heena Individual Interview, 21 August 2017)

The science syllabus articulates that:

> in order to ensure that children receive a rich learning experience, it is important that science teachers become familiar with the outcomes and indicators at each level and have an understanding of how these are translated and implemented in the classroom. (NIE, 2015a, p. 11)

However, it seems that familiarity in translations can be problematic because teachers' **understanding of the curriculum requirements depends on teachers' confidence with the science content and the knowledge and experience that comes from their teaching specialism background.**

The goal is to 'cover' the curriculum.

A feature common across most of the participants when they talked about their use of the curriculum was to refer to their practice as 'covering' the curriculum. Heena (ET) talked about how she used the curriculum:

> I thought maybe we can move faster in the other strands and cover the syllabus sooner.
>
> (Translated Heena Individual Interview, 21 August 2017)

Such a discourse in the use of curriculum is emblematic in content-heavy curricula where teachers are expected to 'run the course' of the curriculum marathon (which is more like a triathlon) without a moment to pause and reflect on students' learning or their own pedagogical practices.

Existing practices meet new curriculum.

Teachers seem to be doing an interesting choreography, incorporating the new curricular requirements in their practice and yet following the old practice of content-focussed teaching. This 'dance' was a significant feature of science teaching identified by the teachers, though more common across some schools than others. The hybrid practice brought out an interesting blend of exam-focussed teaching alongside activity-based teaching. According to the teachers, one of the rationales for this practice was because of parental expectations for 'learning content', as demonstrated by students' 'heavy lesson-notes', prompting teachers to dictate or provide printed lesson-notes and offer comprehensive quizzes/tests as summative assessments. Over time, teachers tend to reflect these views. Dhaha (ET) pointed out:

> When we don't emphasise to the students that there is a test coming up, they don't pay attention to learning the content, they just play-around during the activities and end up learning nothing from it.
>
> (Translated Dhaha Individual Interview, 6 August 2017)

Often, these tests are comprehension-level, pen-and-paper tests that are graded and fail to provide formative learning feedback. Dheena (CT) reflected that:

> This curriculum is good, but I fear that this is moving away from student-learning facts and science content… before with the old curriculum students can answer better to the questions we asked, we knew and saw from end-of-the-unit tests students have learnt these content, but now we don't. So, we decided we will still conduct such tests, inform students of this, but yes, these marks will not be reported as numbers in the student reports, but it works in the students learning the content… and parents are also happy that way
>
> (Translated Dheena Individual Interview, 13 August 2017).

These practices demonstrate that the curriculum aspirations of good science teaching are different than what teachers can practice. Teachers' practices are not only determined by curriculum prescriptions but also by demands made on them by parents, together with their own familiarity and confidence in teaching science. Thus, content-driven, exam-focussed teaching, representative of formalistic pedagogies in science education, tends to prevail despite changes to curriculum which have attempted to shift pedagogies towards flexible LCE. Roberts (1988) synthesised similar observations in the contexts of the UK, USA, and Australia. He concluded that, despite the fact that the curriculum makes provisions to focus on SPS, teachers frequently continue the same practices of content-based teaching that they are comfortable with. He explained that such practices prevail in circumstances where teachers lack confidence and knowledge of science. Mansour (2013a, 2013b, 2015) reported similar practices from the Egyptian context. Such practices, according to Guthrie (2015b, 2020) are common in LMICs; as demonstrated from this data, such practices exist in the Maldives too.

In summary, teachers' familiarity and use of the curriculum are impacted by the complex terminologies and the language competencies that the curriculum assumes teachers possess. For teachers with a diploma qualification, and as a generalist teacher teaching science, interpreting these documents written in their second language is taxing. Further, traditional practices are prevalent in the school as the acceptable and possible 'norm', necessitating teachers to mix the 'old' practices with 'new' practices in implementing the curriculum. Additionally, the content-heavy science curriculum forces teacher to 'cover' material without reflecting on learning.

Consequently, there are limited opportunities for teachers to critically expand their pedagogical palette.

6.1.3 Science process skills pedagogies practiced

In this section, teachers' practices of SPS are presented based on the individual science process skill practiced. I identify themes in practice and, where relevant, illustrate them with data excerpts from teacher interviews and annotations on students' work samples.

Basic process skills.

As discussed in Chapter 2, observation skills are crucial for learning science. All of the teachers interviewed expressed that they teach observation skills, while few teachers identified classification and measurement skills as aspects of what they teach in science.

Observation. The skill of observation seems to be the popular science process skill. However, its enactment was limited because the focus tended to be more on using the sense of sight than using other senses since smell, touch, or hearing were not mentioned. To illustrate, Figure 6.1 shows Diana's (NT) explanation of how her observation lesson was conducted, together with a sample of her students' work and my analysis and interpretations of it. The analysis shows that in her lesson, there is provision for expanding how observation was applied in this lesson, and provision for incorporating other SPS (such as measurement). However, Diana's use of drawings to record observations demonstrates her ability to use multiple modes of recording observation data.

Lesson - Fieldtrip to the beach to observe weathering

How the lesson was conducted:

The lesson instructions were:

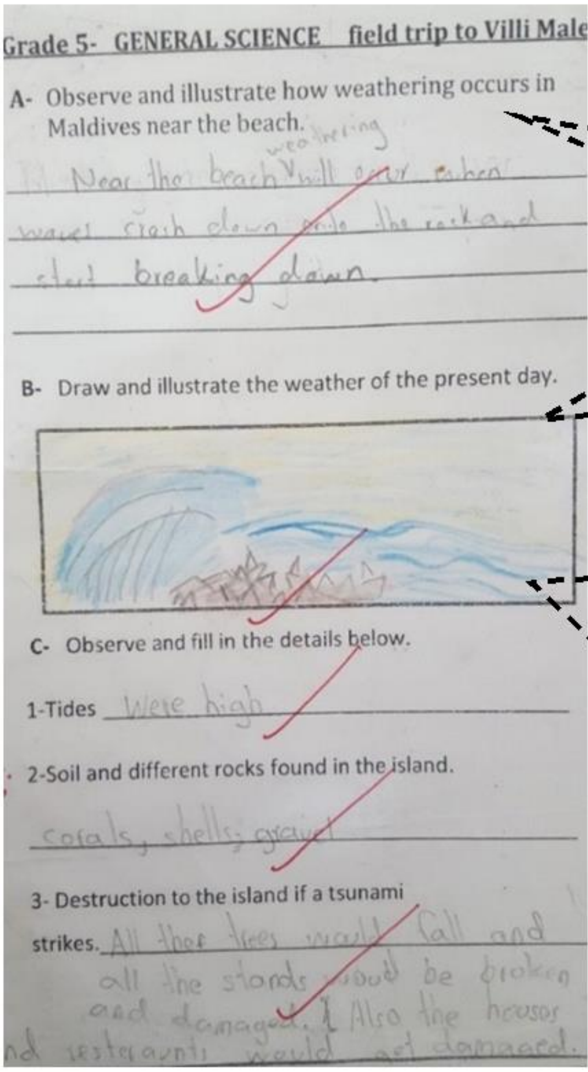
I told the students to observe the beach for anything they see and notice, such as the weather like wind or cloudy, observe the beach for any rubbish and whether they are biodegradable or not, things like that

The follow up:

the students then came back to school [next day] *and discussed and completed the worksheet… and mostly assessment was on what they observed based on the worksheet completion*

(Translated Diana II, 13 August 2017, 13/08/2017)

The students' sample of work


Grade 5- GENERAL SCIENCE field trip to Villi Male

A- Observe and illustrate how weathering occurs in Maldives near the beach.

Near the beach weathering will occur when waves crash down onto the rock and start breaking down.

B- Draw and illustrate the weather of the present day.

C- Observe and fill in the details below.

1-Tides were high

2-Soil and different rocks found in the island.

corals, shells, gravel

3- Destruction to the island if a tsunami strikes. All the trees would fall and all the stands would be broken and damaged. Also the houses and restaurants would get damaged.

My analysis & Interpretations

Most of the tasks focus on **observations**

Drawing as a form of recording observations … **demonstrates variety in observations can be made**

There is provision to

Use senses other than sight to make these observations

Use measurements such as temperature, wind speed

Figure 6.1 Diana's lesson on observation skills.

Similar practices were identified with other novice teachers as well, attributing their pedagogical practice to limited conceptual understanding of science process skill and limited science teaching experience. However, because experienced teachers' practice also demonstrated a similar limitedness in how observations skills were taught, this practice seems common across all of the levels of teachers.

However, as demonstrated by Geela's (ET) lesson and her students' sample work, the limited approach to **conducting observation can also be a conscious pedagogical choice.** Geela expressed that she wanted her students to record observations in writing rather than drawing because she interpreted the curriculum outcome[47] terminology 'record' as a *written* record. She further justified this practice by pointing out that the students' textbook also does not mention any alternative forms for recording data.

Classification. In Section 2.4.2, classification was defined as grouping/ordering objects/events into categories based on their properties or a set criteria. This skill, similar to observation was limited in practice; often, **observation seemed to be in lieu of classification.** To illustrate, Bathool, (CT) discussed a lesson that focussed on observing and classifying different types of rocks based on the rock samples' physical features. When asked about the SPS in the lesson, she replied, 'the children observe *kohgen amillah ah liyunee'* [translation: children observed, and wrote it down, on their own]. Such statements signify the heavy focus on observation skills while classification skills appear secondary. An example of student work from Bathool's class was offered in Figure 5.3 (in Chapter 5), showing the focus on both observation and classification skills in the lesson. Noteworthy here is that her stress of students writing down material on 'their own' is indicative of her adherence to constructivist learning principles of active learning.

[47] The curriculum specified outcomes was 'EB 3.4 – Investigates the physical properties of water' with associated indicator 'describe and illustrate the water cycle using the physical properties of water' (NIE, 2015a, p. 48).

Another ET, Aneega, discussed an excursion lesson to a park (Figure 6.2). According to Angeega, this was a successful lesson as she had employed ideals of constructivist pedagogies in her lesson. However, her understanding seems obfuscated because the structure of the students' sample of work did not reflect such a constructivist inquiry-approach but rather demonstrated a fragmented application of both observation and classification in her lesson. As previously presented, **teachers are aware of the theories of constructivist pedagogies, but there seems to be a limited application of these in pedagogical practice.** Such limited practices signal **a gap between teachers' conceptual understanding and their application**.

Lesson - Excursion to the park

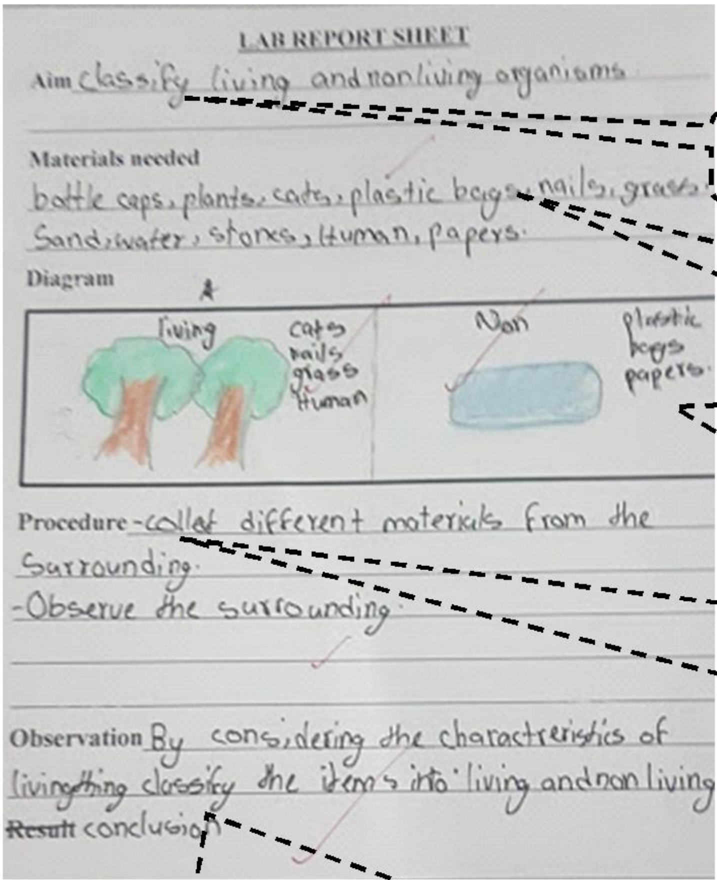
How the lesson was conducted:

At the beach, the students were instructed to note or collect materials that they see in their surroundings. Upon returning to the class, she instructed the students to classifying them based on criteria of living/non-living things.

> *Here I did not explain anything about the content of the lesson just gave instruction on the activity and doing like this made students interested....even the weaker students participated in collecting and completing the worksheet... unlike numeracy and literacy, in these lessons I could explain in Divehi and then they understand so then they can participate in the lesson*

(Translated Aneega II, 2 August 2017)

The students' sample of work



My analysis & Interpretations

Aim is on **classification skills**

Students have listed what they **observed** at the park

This signifies some classification, but it is not explicitly addressed here

The template used for this activity may not be appropriate as students are not given a list of materials nor a 'procedure' as in an experiment

Here as observation, what is written is more as what the students did. A bit unclear on how observation and classification is being connected.

Figure 6.2 Aneega's lesson on observation and classification skills.

Measurement. Although experienced teachers who are also science coordinators (such as Faheema and Hala) mentioned using measurement skills and students' work samples reflected the application of this skill, **measurement skill was also narrow in practice.** Similar to classification, measurement skill was either briefly applied in the lesson or **used in lieu of observation skills.**

To illustrate, Hala and Heena (from the same school) discussed a series of lessons they co-planned and conducted. Interpreting from their interviews, it was evident that these lessons subscribed to elements of constructivist pedagogy. Further, by design of these lessons, there was potential to incorporate and integrate numerous SPS with the science content. However, the teachers explained that 'students only observed how the compost bin was decomposing over time and measured how the seedling they planted in it grew', emphasising two skills: *observation* and *measuring (*see Figure 6.3 for student work sample)*.* I asked Hala to explain how measurement skills were practiced:

> Hala: On fourth week it [the food-waste in the compost bin] was badly decomposed and on fifth week we planted a seedling in it and then we looked how the plant was growing.
>
> Me: How did the students do this?
>
> Hala: We checked how it was growing, you know
>
> Me: So, what exactly did students do, in checking plant growth?
>
> Hala: What do you mean?
>
> Me: Did they do any measuring here?
>
> Hala: Oh yes, I asked students to use a ruler and note it's [the plant] height. But it was a tiny plant
>
> Me: How did they do this? Any particular focus on measurement skills, and the units?
>
> Hala: We had two set-ups in the class, so two students would measure it and report to the class, and we all noted it in our records. You can see this in the student notes

(Translated Hala Individual Interview, 21 August 2017)

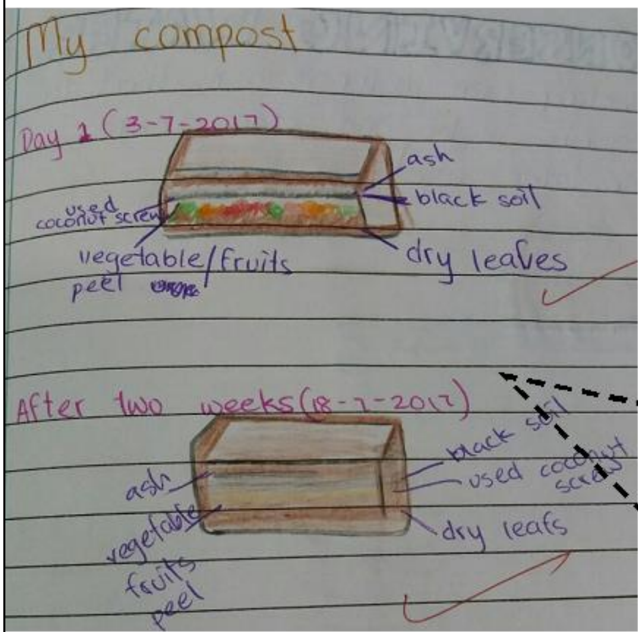
Lesson – Making compost

How the lesson was conducted:

The lessons were on making and using organic compost. Teachers together with the students identified a problem in the island: the excess food-waste disposal, (common in the Maldives during the month of Ramadan). The lessons started in Ramadan and continued after the month. To solve this problem, teachers got students to identify a use of these food-wastes – compost. Next they moved to experiment such composts' effects on soil-fertility, by making compost and growing some seedlings in compost enriched soil.

Composed from Heena & Hala interviews (21 August 2017)

Student's sample of work



My analysis & Interpretations

Student has made **observations** on the colour of the soil (black), and in the diagram has represented what had happened to the vegetable and fruit peels before and after.

I wasn't sure where the measurement was although she mentioned students did some measuring

Figure 6.3 Hala's lesson on observing and measuring skills.

Faheema, expressed an interesting view on measurement skills. Analysis of the work sample prompted me to ask Faheema about the nature of measurement skills she was teaching to see if she focussed on units, multiple trials, and accuracy in measurement. Faheema explained that because her students could measure out the required amount of water (100ml), she was confident that her students had learnt measurement skills.

Overall, for teachers, there exists a limited awareness of the SPS because perhaps teachers themselves have a limited understanding of the individual skills and how they connect these skills together. In a similar study conducted in a Thai context, it was reported that classification skills were one of the least taught basic skills in the classroom, regardless of the skill being present in the content or lesson design (Elmas, Öztürk, Irmak, & Cobern, 2014). Thus, it seems that though teachers may be provided with curricular opportunities to incorporate science process skill in their lessons, **their limited conceptual and procedural understanding of science and the skills, together with the unfamiliarity to the curriculum requirements, push their focus on the one or two basic science skills, often manifesting as a variation of observation skills.**

Integrated science process skills.

Integrated skills combine SPS together with high order thinking skills and advanced manipulations of materials. The most common integrated skills that teachers had identified and represented in their students' work were experimentation and science-investigations.

Experimenting. Teachers conducted experiments as teacher-led whole class demonstrations or in groups (size 4 to 6 students), which was determined by the availability of materials (most teachers identified this as the reason), or the complicatedness of the process (Dheena and Dhaha identified this). Teachers such as Dhaha (ET) **expressed how experiments can make learning memorable and provide continuity in learning** across school and home. However, though teachers advocated for conducting experiments in the class, examining their students' work samples from these lessons demonstrated that **teachers tend to practice a limited idea of experimenting**. As shown below in Figure 6.4, Enaz (NT) had structured the experiment where basic skills of observation and making predictions and inferences were possible through the design of the activity, but experimenting seemed to limit focus on only the skill of observation.

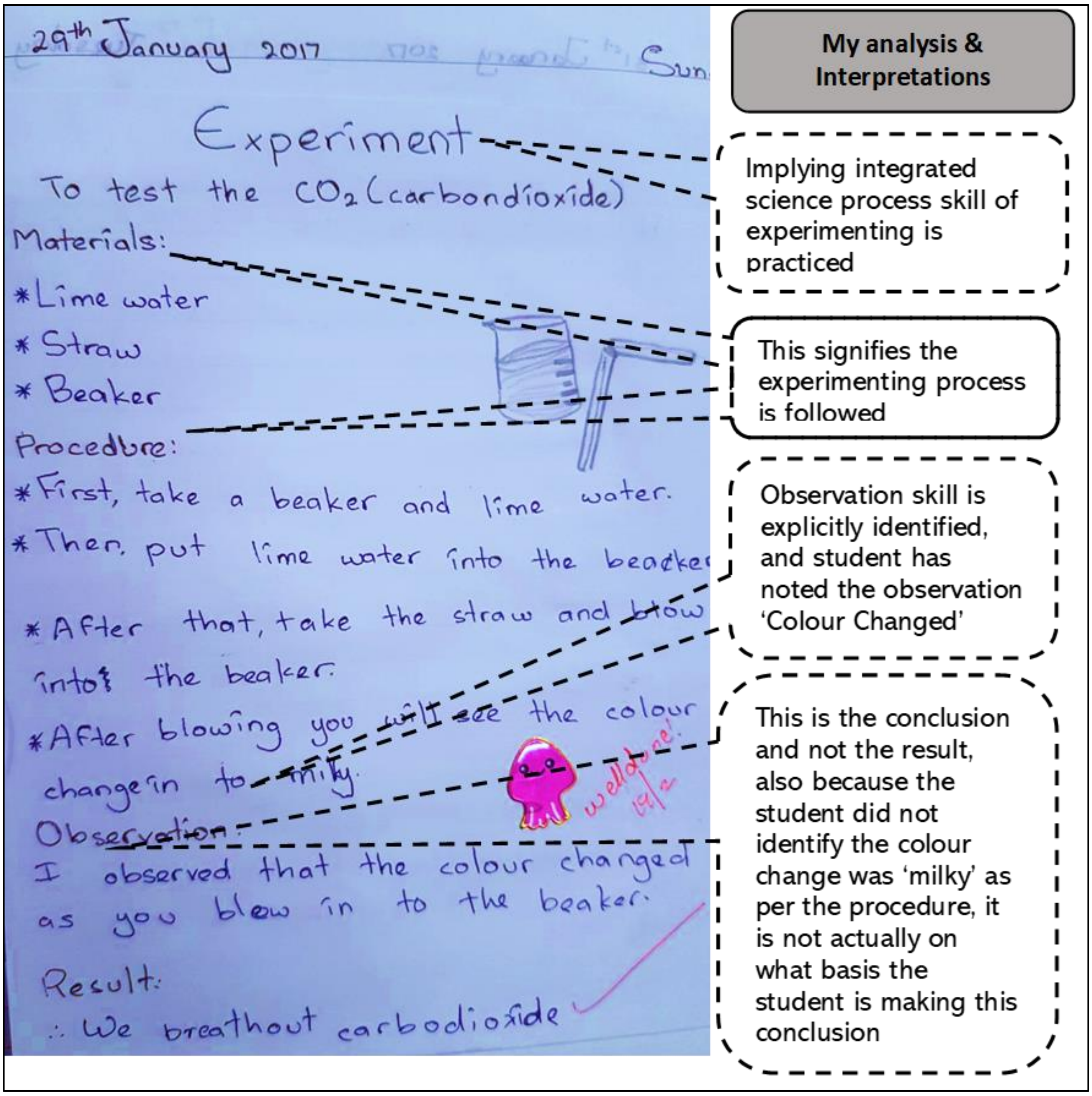


Figure 6.4 Enaz's lesson on experimenting skills.

Investigating. Investigation brings together most of the SPS and is taught through a science-investigation-based approach. This can be either as guided investigations or open investigations. Guided investigations provide a closed structure to the students, for example where the methods/procedure are pre-identified or there is heavy teacher input and scaffolding. On the other hand, open-investigations are highly flexible and students are provided with less structure from their teachers. Amongst the teachers in this phase of the study, **the more structured type of investigative lessons was common.**

Faheema (ET) demonstrated sound procedural and conceptual understandings of the SPS through her design of an investigation lesson. Figure 6.5 presents the overview of this lesson and my analysis on her student's work sample. According to Faheema:

> Students wrote their own steps, but I first explained [each step] …writing these steps are important I told them.
>
> (Translated Faheema Individual Interview, 6 August 2017)

This statement demonstrates her knowledge of designing experiments as a key component of investigations and also the importance she places on students' independent work. As discussed in Chapter 2, enabling students' independence in learning is a constructivist pedagogical principle. Faheema's understanding of the progressive nature of how students learn and acquire these SPS demonstrates a sound knowledge of the pedagogical application of these skills.

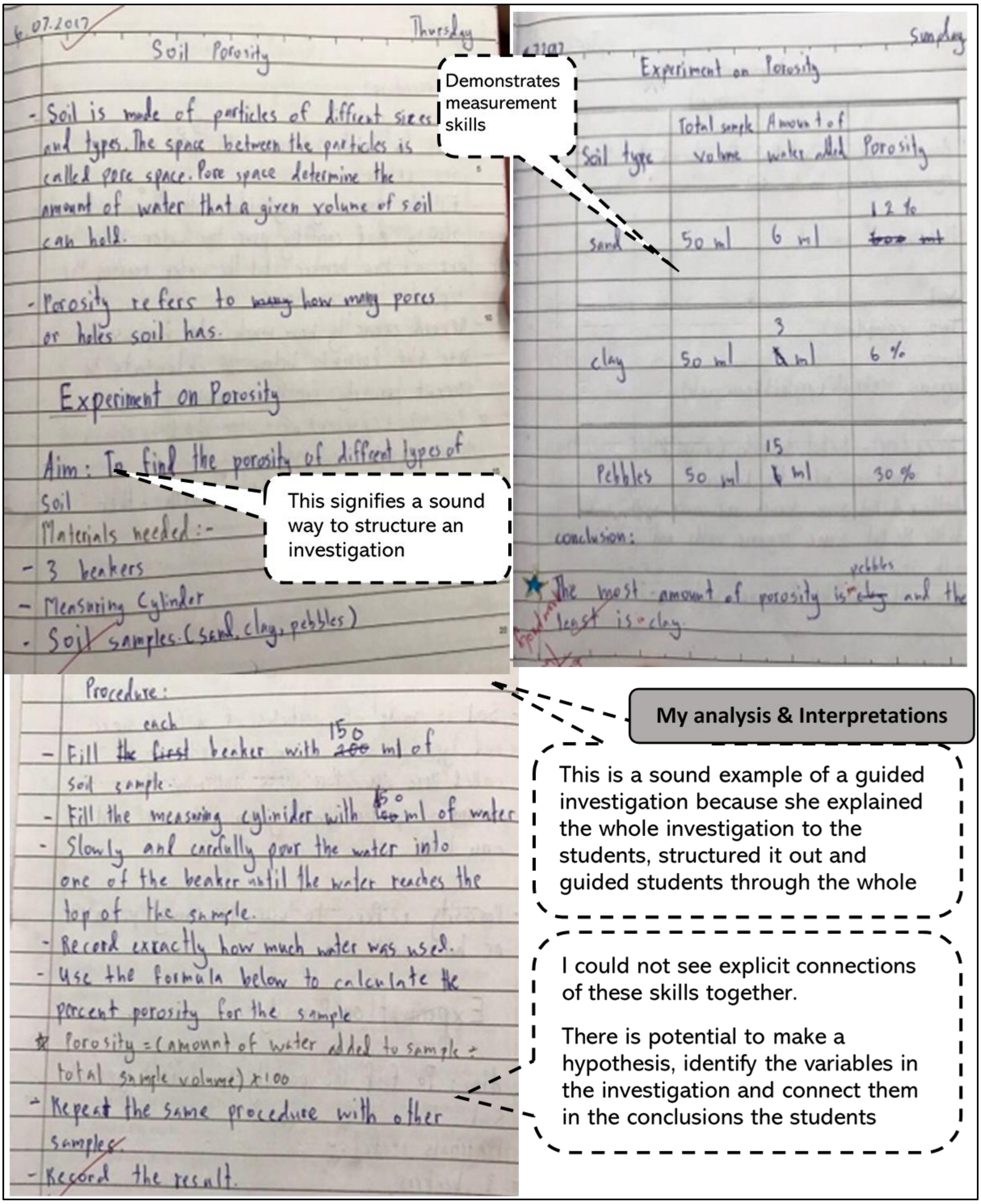


Figure 6.5 Faheema's lesson on investigation skills.

Assessment practices.

Most of the student's-sample-of-work that the teachers shared was 'marked', a common performative practice that teachers are required to do. The purpose of this practice is for teachers to provide formative feedback on students' notes, activity sheets, and any other form of learning product. However, the formative feedback took a different turn and, as demonstrated in the work samples presented in this chapter, they are either a red tick (seen on Figures 6.1, 6.2, 6.3, 6.4, and 6.5), a sticker (seen on Figures 6.4 and 6.5) or marked with a short comment such as 'well-done'/'great-work' (seen on Figures 6.4 and 6.5). Such 'marking' practices are emblematic of 'one-answer-all' approaches that were evident across the samples of student work that each teacher provided.

Although the curriculum prescribes multiple forms of formative and summative assessments in teaching science and SPS, these **teachers expressed that process skills were often used in the classroom teaching and learning activities** where formative assessments are informally done; for formal summative assessments they focus on the content. Such practices denote the existence of formalistic traditional pedagogies inherent in the culture of schooling in the Maldives, as discussed in Chapter 4.

Challenges to teaching SPS.

Teachers were eager to discuss challenges and school-level systemic difficulties to teach SPS. **The systemic challenges they identified include limited time (for planning and classroom instruction), lack of laboratory resources, lack of expert support and the large student number in one class** (30 to 35 students). Such systemic issues were also identified by the TEs and CDs (discussed earlier in this chapter) and are common hinderances to any science curriculum innovation. These challenges have been reported in a variety of contexts, for example in Malaysia (Rauf et al., 2013), Indonesia (Permanasari & Hamidah, 2013), India (B. Thomas & Watters, 2015), USA (Keil et al., 2009), Turkey (Saka, Sürmeli, & Öztuna, 2009; Turkmen, 2013), and the Maldives (Shiyama, 2016)). Further challenges identified from this phase are presented below.

Novice teachers' dilemmas. Novice teachers such as Diana and Enaz identified **challenges such as feelings of incompetence associated with a perceived lack of science content knowledge and experience.** For Diana in particular, the limited knowledge and experiences posed difficulties in her first year:

> I don't know much science personally so need a lot of time to prepare and study. Every day I go home and study for the next day's science lessons and I spend more time on preparing for my science lessons that any other subject. Students ask questions and I feel inadequate if I cannot answer them, so I prepare a lot…. but there are different levels and depth of information out there, so it confuses me more, then I go ask others, like friends…. In coordination meeting we don't discuss much in detail the content to teach and I feel lost and confused at times, and I have already done a silly mistake because of it.
>
> (Translated Diana Individual Interview, 13 August 2017)

The particular incident Diana referred to here was also highlighted by Dheena in her interview. For the purpose of bringing its significance on how (beginning) teachers' misconceptions about the science content may pose significant hinderances to them in teaching, the incident is described in this entry from my research journal.

> The grade 5 teachers in School D planned to conduct an experiment on testing the presence of carbon dioxide in exhaled air. Materials identified in the common activity sheet and shared lesson plan were a test-tube with limewater and a straw.
>
> Limewater here was referred to a solution of calcium hydroxide, not a literal solution of limewater (lime-juice). In the coordination meeting it was assumed everyone understood what limewater meant, but unfortunately Diana did not. On the day of the lesson, from home she brought solutions of some lime-juice in water for her students to experiment on. This could have been avoided if the lesson was discussed in detail, practised beforehand or simply if Diana had read some background information about it. This was a significant and bitter lesson learnt for the team, particularly for Diana, as a first-year teacher. Sadly, this added to her feeling of incompetence and dislike to teaching science.
>
> (Research Journal, 20 August 2017)

Discontinuity in SPS pedagogies across the curriculum. Enaz pointed out an interesting challenge: **a discontinuity in teaching SPS across the curriculum**, making it harder for teachers and students to 'pick it' at Key Stage 2.

> It is very difficult to teach this way in this grade because students don't do this from the beginning. Starting from grade one on they are not exposed to learn science this way, so they are reluctant to do these things in class, like touch things. It is likely that this is because they are not exposed to such things even at students' early ages, like in pre-school. So, it is difficult taking such students on fieldtrips and getting them to use their own skills to do something independently.

(Translated Enaz Individual Interview, 10 August 2017)

Further, **access to the laboratory** seems to be a significant challenge for teachers when they are in the afternoon teaching session.

> We have to talk to the lab assistant and work with her schedule of her afternoon schedule and then plan our lab activities. The school cannot hire an afternoon session lab technician so often times we then avoid using lab

(Translated Dhaha Individual Interview, 6 August 2017)

Limited laboratory access can not only limit teachers' choices of pedagogies to utilise but can also have a negative impact on their motivation to teach science. Consequently, teachers tend teach science teaching as 'chalk-and-talk' by default.

In summary, teachers' pedagogical practices in teaching SPS demonstrate teachers' attempts and awareness of incorporating them in their science teaching. However, various limitations tend to narrow their focus to basic science skills such as observing. Consequently, teachers work with a limited palette of pedagogies. It is noteworthy here to point out, teachers' SPS pedagogies were not school-specific nor connected to their educational qualification.

6.1.4 Section conclusion

The findings presented in this section can be summarised into three key points. **Firstly, generalist primary teachers have a limited conceptualisation of SPS and its ontological and epistemological place in science and science education.** The understanding is limited to basic SPS such as observing, measuring, and classifying. Such a narrow conceptualisation of SPS constraints teachers' own development of these skills and their pedagogical application of these skills. **Secondly, the practice of using students' textbooks as proxy for curriculum/syllabus outcomes to guide classroom practice is common among teachers, because the curriculum itself is laden with complex language and terminologies, which makes challenging its interpretation and translation into practice**. Further, curricular requirements tend to be misunderstood or misinterpreted by the teachers. These findings echo similar research findings such as Rauf et al. (2013) and Shahali et al. (2017).

Further, most teachers' classroom teaching and learning activities demonstrate constructivist pedagogical elements such as active learning; however, teachers have a tendency to employ these activities as a reinforcement activity in their teaching and learning sequence. Reporting from the Botswanan context, Emereole, (2009) explained that such practices of procedural teaching of SPS limits the use of SPS to a verification tool for scientific concepts rather than as a tool to acquire scientific knowledge.

Thirdly, limited views and practices are exacerbated by numerous systemic and professional challenges that generalist teachers face in teaching SPS. Thus, any professional learning support that are developed for generalist teachers in teaching science has to explore possibilities of overcoming or minimising these challenges within the constraints of teachers' pedagogical background and experiences.

Section 6.2 From TPD towards TPL

This section presents findings pertinent to current practices and discourses on teacher professional development (PD) and learning. The purpose of this line of inquiry was to gather evidence on teachers' current experiences and aspirations for professional learning needs in order to inform the design of a bespoke teacher professional learning engagement for Phase Two of this study.

Teachers expressed their frustration with how their schools offer professional learning support. Similar to what discussed in Chapter 4, most of these teachers experience one-shot, workshop-style PDs on generic topics such as 'classroom management'. As discussed in Chapter 3, these are transmissive modes of teacher learning that subscribe to teacher professional development in lieu of learning. Such practices overlook teachers' needs for learning because these managerial teacher professionalism practices tend to view teachers from a deficit perspective. As discussed in Chapter 3, democratic teacher professionalism practices alternatively promote TPL as holistic learning that empowers teachers in their pedagogical praxis. Thus, in this section, I present findings that focus on teachers' aspirations for such forms of professional learning. On analysing the data, three major themes were identified. They are presented below.

6.2.1 Supporting the translation of pedagogy as prescribed to pedagogy as enacted/experienced

As discussed in Section 6.1, teachers had expressed difficulties in interpreting the curriculum prescriptions. In relation to this difficulty, teachers identified that **useful professional development and learning ought to support their interpretation of the curriculum**, the syllabus documents, and other curriculum related resources. Interestingly, this was voiced by teachers from all levels of teaching experience.

Teacher educators (TEs) too highlighted the importance of connecting teacher professional development to the prescribed curriculum. They pointed out that teachers need to learn these process skills through application, both in their own learning and in their classroom pedagogies. Curriculum developer (CD) Mina stressed that in-service teacher professional development needs to address areas of teacher-needs, but she also pointed out that there is a lack of personnel in the country who can conduct these school-specific professional development activities.

6.2.2 'Expertise' support

Teachers indicated that curriculum support or subject-specific support needs to come from 'experts', such as curriculum developers. Heena (ET) expressed:

> We struggle to get expert opinions and input on things like water and waste management and sometimes when we take students on field trips to places such as waste management sites, we also learn new things…If we knew them before it would be more useful to plan lessons.
>
> (Translated Heena Individual Interview, 21 August 2017)

Similarly, Faheema (ET) articulated that some of this subject-specific external support could come through local institutions who provide services such as waste management, electricity generation, or green-tourism:

> Yes, for us, subject specific professional development is needed... maybe [focussing on] teaching science will be helpful. How can we do experiments, best ways to do them in class, hints, tips on doing these... Things like how we can do field trips and best ways to do them….in coordination meeting having [such] an expert input would be very helpful.
>
> (Translated Faheema Individual Interview, 6 August 2017)

Diana (NT) further argued for her, 'expert' support can come from her colleagues as well:

> I would like to observe a peer's lesson. Discuss how each topic goes without assuming we will know…. [get] more guidance and to explain like how to use, as we studied in pre-service.
>
> (Translated Diana Individual Interview, 13 August 2017)

The need to have 'expert' support on teaching and interpreting the curriculum can be considered in two ways. First, on a negative note, it can promote teachers' viewing themselves in deficit and seeking this expert from the outside of their immediate teacher community in the school, undervaluing their experience base.

Secondly, on a positive note, this 'expert' support can also be a mechanism through which teachers can apply their classroom teaching to various local service industries, or to tap on the expertise of their peers. **Such a connection helps to strengthen the teacher community and build connection**s to the local community where science learning is applicable, thereby making school science relevant to students' daily lives.

6.2.3 Development of SPS

Teachers expressed that the professional development support they seek should enhance their understanding of SPS and enable them to explore multiple pedagogies to teach these skills. Diana (NT) expressed that support she seeks would enhance her science content knowledge, especially her science pedagogies. Similarly, Geela (ET), after pointing out her difficulties in interpreting the curriculum, explained her professional learning need as:

> Focussing on integrating and team-teaching with a focus on skills.
>
> (Translated Geela Individual Interview, 1 August 2017)

When inquired on the specifics of these skills, teachers (such as Aneega, Diana, and Bathool) expressed the need to learn SPS such as analysing and interpreting. Experienced teachers such as Cary, Dheena, Dhaha, Enaz, Faheema, and Heena expressed their need to learn about science investigation procedures. In particular, Dhaha expressed that she would like professional development to be

> something where we actively participate, practise the skills in them [PDs] the way it is supposed to be taught in the classrooms.
>
> (Translated Dhaha Individual Interview, 6 August 2017)

Such aspirations imply that teachers seem confident in how they teach basic SPS, but they **seek professional learning support in teaching the integrated SPS through supportive and guided experiences**.

Additionally, the CDs and TEs discussed similar ideas. Both groups emphasised the need for content-specific professional development activities that focus on the subject-specific pedagogical needs of the teachers. Kamana (TE) expressed that

> PDs has to be on conducting workshops, day-long ones, by the experts directly to the teachers. Focus on the process skills. Take different activities from the curriculum and get them to practise…They **just need more practise into these skills**, exposure in them so they know how and where they are used.
>
> (Translated Teacher Educators Group Interview 6 August 2017)

Based on the findings presented in this section, three aspects of TPL were identified. Firstly, the professional learning activities have to focus on the science curriculum content. Secondly, the content of the professional learning activities has to be strongly connected to developing teachers' science content and associated pedagogies. Thirdly, because teachers value 'expert' input in these professional learning activities, any professional development learning support that is considered credible for the teachers should focus on this expertise both from outside and inside their immediate teacher communities.

Section 6.3 Implications for Phase Two: *Design considerations*

In this section I briefly discuss on my personal reflection on how I was interpreting the data from this phase, considering its impact on the development of Phase Two of data collection. I also comment on my changing identities as a researcher.

6.3.1 Reflecting on my identities and roles

During the interviews, I noticed teachers were uncomfortable to freely talk about their understanding of the curriculum. I felt that teachers were defensive and brief in how they were explaining their practice, and knowledge of the curricular documents and SPS pedagogies. Though I tried to explain my role was not to evaluate or judge them, I suppose in their 'gaze' I will always be an 'authority' person, and perhaps to an extent I was subconsciously presenting myself as such.

Following the data collection for this phase, I started considering where my researcher role in this study was taking me. I had identified conflicts and I knew that the identity I assume would heavily impact Phase Two. My guiding principle at this point was the epistemology behind participatory research. I wrote in my research journal:

> I feel I can relate with views of TEs and CDs more because I used to be one of 'them'. But now I need to take off the old hat and put on my researcher hat…especially for phase two this is urgent as I am about to develop these teacher professional learning activities.
>
> In the dialogues with TEs and CDs, I am noticing how they identify faults or issues with teachers' practices, often not reflecting their own practices, and blaming another source (often teachers) for the poor quality of science education practices in primary schools. This is a blame game viewing teacher in deficit-models. I think I was of this ignorant discourse looking down on teachers as 'have-nots', that need to be fixed. So I have been uncritically stuffing my 'innovative' progressive pedagogies down teacher's throats, without considering how they were experiencing them nor how culturally applicable they were to us Maldivians. This is my TE hat. I need to put my researcher hat now.
>
> With the research skills I am learning, I see I need to remove these prejudices, especially in how I take these findings to phase two. I have to remember I am researcher and a professional learning facilitator. I have to follow the participatory research methodology protocol as my guide so I can avoid my TE practices

of 'telling' teachers what to do, to working with them as co-workers to develop our collective practices.

(Research Journal, 10 January 2018)

These reflections enabled me to understand that teachers' poor conceptualisation of SPS and associated pedagogies is not because teachers are unpassionate or do not care about teaching science. The practice of teaching science through generalist teacher training and other various systemic level issues and challenges may not change, but we can change our practices and views of these systemic issues. So as 'experts', our responsibilities are to find ways and means to support teachers in providing quality learning experience for their students. We need to include teachers as part of our professional communities and networks. We need to establish a supportive mechanism that rather than critiquing teachers' (in)competencies, we should constructively guide the teachers to enhance their capacities and competencies of teaching SPS.

6.3.2 Considerations for designing the professional learning

Teacher interviews and samples of their students' work indicated that when teachers plan science lessons, SPS is not a major focus of the teaching and learning activities. Shahali et al. (2017) explained that this practice is also is due to the limited conceptual understanding of SPS. Rauf et al. (2013) from the Malaysian context observed that when upper primary teachers' conceptual understanding is limited, they tend to assume that by doing activities in the classrooms, students learn these skills by default. However, students cannot learn nor develop their own conceptual and operational knowledge of these skills (Farsakoglu et al., 2012; Rauf et al., 2013; Shahali et al., 2017) through such pedagogical approaches. Harlen (2001, 2004) argued that teachers need to be explicit about the SPS they are incorporating in their lessons. Such explicit instructions are more likely to follow if teachers are aware of how the SPS are integrated through and in the activities, such as in the design of the worksheets and activities they use in their classrooms. **Thus, the purpose and content of the teacher professional development activities have to explore ways to support teachers' conceptual and procedural understanding**

of these skills, at the same time exploring ways in which they can explicitly incorporate these skills in the design of their lessons.

Another significant finding from Phase One to consider in the design of Phase Two **was working WITH teachers to developing their understanding** and development of integrated SPS such as hypothesizing, defining variables, or experimenting, echoing findings from different contexts with primary teachers (Aydoğdu, 2015; Rauf et al., 2013; Shahali et al., 2017). Further, as discussed in Chapter 2**, using SIBA to teach SPS is an amalgam of the individual SPS that provides a coherent teaching structur**e. As such, this structure focusses on the development of SPS by providing a holistic learning experience that enable the learner to understand the science content and develop their SPS in-situ. Supporting teachers in the use of science-investigation-based approach to teaching SPS provides teachers opportunities to enhance their own conceptual and operational knowledge of the SPS. Thus, the science-investigation-based approach to teaching SPS will be the pedagogy explored in Phase Two.

Furthermore, in Chapter 3 the literature reviewed has indicated that TPL is a social, participatory, and democratic endeavour where individual and collective learning are important. Additionally, it was also argued that teacher learning has to consider activities that offer combinations of formal/informal learning, planned/unplanned learning, and structured/unstructured activities. These features, together with those findings presented in Section 6.2 of this chapter informs the approach and activities that will form the basis of the bespoke Phase Two TPL engagement. Figure 6.6 summarises these considerations made towards the design of these activities.

Teacher Professional Learning

Why are we doing it? (PURPOSE)	How will we do it? (CONTENT)	How will it look like? (APPROACH)	What will we do? (ACTIVIITES)
•Developing teachers' conceptual and procedural understanding of science process skills •Applying curriculum prescriptions of skill-based learning into our design of lessons • Connect the learning to immediate classroom use	•Science-investigation-based approaches to science process skills pedagogies •Constructivist pedagogies for science education	•Social, participatory approaches considering collective and individual learning •practices of democratic professionalism	•Co-planning lessons for explicit incorporation of science process skills •Reflecting on these lessons focussing on how skills are developed, taught and learnt •Developing individual teachers' understating and application of these skills

Features of professional learning discussed in Chapter three – combinations of **formal-informal learning, product-process of learning, planned-unplanned learning, structured-unstructured learning**

Figure 6.6 Implications of Phase One findings for Phase Two development.

Conclusion

In this chapter, findings pertinent to the design and development of a teacher professional learning engagement to explore contextualised application of SPS pedagogies were presented. To do so, teachers' current practices of SPS pedagogies were explored to **inform the purpose and content** of this professional learning engagement. Three findings are significant to the design of this professional learning engagement. Firstly, generalist primary teachers have a limited conceptualisation of SPS. Secondly, because of the complex language and terminologies used in the curriculum documents, the interpretation and translation of the curriculum outcomes into practice is challenging. Thirdly, these practices are further exacerbated by the systemic and professional challenges generalist teachers face in teaching science outside of their specialism.

Further, teachers' aspirations for professional learning of SPS were explored to **inform the approach and structure of activities** of the professional learning engagement that was going to be developed for this study. The findings point out that generalist primary teachers seek support in developing knowledge of SPS and associated pedagogies, together with understating the use of curriculum documents to inform their classroom pedagogies.

Thus, the purpose, content, approach, and structure of the professional learning activities were developed, informed by these findings together with the literature reviewed in Chapters 2 and 3. These design features were also shaped by the participatory nature of this inquiry. In the next chapter, findings from the development and implementation of this professional learning engagement are presented.

Chapter 7. Designing and Implementing Teacher Professional Learning

> Professional learning is valued when teachers are given high regard in their learning processes.
>
> (Gutierez, 2016, p. 813)

Introduction

The aim of this research was to explore upper primary (Grades 5 to 6) teachers' professional learning of pedagogies for science process skills (SPS). In the literature reviewed in Chapters 2 and 3, it was identified that, when providing professional learning support in teaching science for generalist primary teachers, the professional learning has to be *relevant* in order to develop teachers' pedagogical praxis. Chapter 6 offered empirical findings to inform the development of a professional learning engagement to explore generalist teachers' pedagogical praxis of SPS. The purpose of this chapter is to present findings regarding the design, planning, and implementation of the previously mentioned bespoke teacher professional learning engagement implemented in Phase Two of this study.

Three aspects are highlighted in this chapter. Firstly, in Section 7.1, the findings focus on the criticality required when designing and planning the professional learning activities. Secondly, in Section 7.2, findings pertinent to how the individual activities were designed and adopted are presented to highlight the need for context-specific contingencies at all the stages of the professional learning inquiry. Finally, in Section 7.3 and Section 7.4, the overall implementation of the professional learning inquiry is presented, highlighting how the different activities were integrated into the collective learning experience, comprising seven learning/activity cycles.

Section 7.1 Designing and planning for professional learning

In this section, findings on the initial designing and planning of the bespoke Phase Two professional learning activities are presented. I incorporated findings from Chapter 6 and the literature reviewed in Chapter 3. In particular, elements of social learning theory and features of professional learning were considered to identify the different learning activities, modalities, frequency, and purpose for teachers' pedagogical praxis as well as their professional learning. These considerations are summarised in Table 7.1. Although the theory components and features of learning are mapped directly to these activities here, the learning activities incorporated most of the theory components and features of professional learning, because in this study learning is conceptualised as subjective and contextually contingent.

Table 7.1 Overview of the professional learning activities.

<table>
<tr><th>Learning activity</th><th>Modality</th><th>Component of social learning theory (Wenger, 1998)</th><th colspan="2">Feature of professional learning addressed</th></tr>
<tr><td>Co- developing teaching resources</td><td>Mostly collective</td><td>Identity and Becoming
Doing and Practice</td><td>Gaining ownership of the learning
Learning as a social enterprise</td><td rowspan="4">Most of these activities work on collaborative, collegial practices

The focus of the learning is teachers' pedagogical skills for teaching SPS

Learning is ongoing, flexible and sustained</td></tr>
<tr><td>Reflecting on practice and learning</td><td>Collective and Individual</td><td>Identity and Becoming
Experience and Meaning</td><td>Connecting classroom-practice to learning
Learning as a social enterprise</td></tr>
<tr><td>Classroom observations</td><td>Collective and Individual</td><td>Doing and Practice
Experience and Meaning</td><td>Connecting classroom-practice to learning</td></tr>
<tr><td>Goal setting</td><td>Individual</td><td>Experience and Meaning</td><td>Connecting classroom-practice to learning
Gaining ownership of the learning</td></tr>
</table>

Demonstration lesson	Mostly collective	Experience and Meaning Identity and Becoming	Coaching/mentoring	There are multiple learning opportunities
Teacher-led classroom-research	Individual	Experience and Meaning Doing and Practice	Action-research as evidence-based for learning Connecting classroom-practice to learning Gaining ownership of the learning	

Based on this mapping, features of professional learning distinctive to this study were developed. As shown in Figure 7.1, these features highlight both the individual and social natures of learning while also promoting teacher professionalism practices.

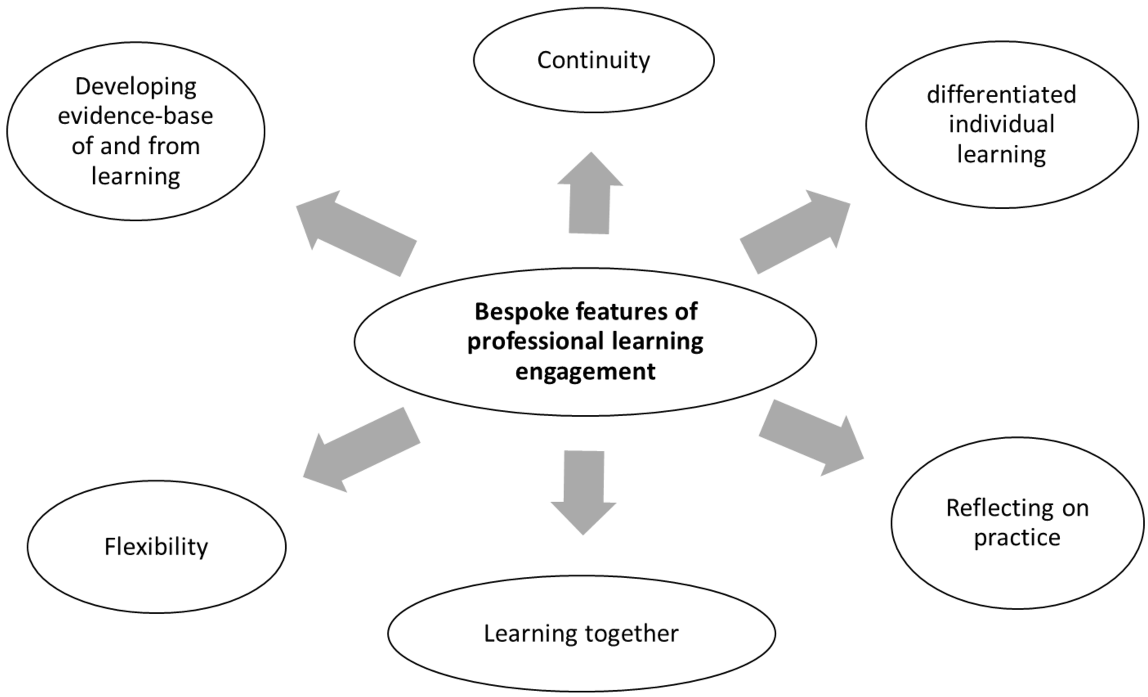


Figure 7.1 Feature of the professional learning engagement.

At this design stage, based on findings from Phase One (presented in Chapter 6), three deliberations influenced the construction of these activities. Firstly, to familiarise teachers with the science curriculum (content and pedagogies specified), co-developing teaching materials were to be based on the curriculum, discussing the implementations of these teaching materials, revising them for continuity and sustained support through the six-month long professional learning engagement. In these activities, both teachers' expertise and my professional knowledge (as professional development provider) combined to support the development of the activity and our collective learning.

Secondly, these activities were integrated, as much as possible, into teachers' daily school schedules so that they would not become an additional stress for the teachers (Ball & Cohen, David, 1999). Further, such integration also enables teachers to view professional development and learning as embedded in practice and moves it away from functioning just as formal, non-contextualised activities.

Thirdly, these professional learning activities were to be centred around exploring science-investigation-based lessons because this is a constructivist pedagogy that would also enable the explicit focus on teaching SPS. The development and implementation of these activities are presented later in Section 7.5. Here, I focus on initial school-level development features that were considered.

7.1.1 School-based further planning

As highlighted in Chapter 5, during the Phase One data collection stage, I established that School D was interested in working in this research and participating in the professional learning engagement activities. In Figure 7.2 below, a brief description of the school is provided. These features were significant in both the development and implementation of the professional learning activities.

Once the school for Phase Two was established, it was important that I considered the teachers' science teaching schedules in further designing the professional learning activities. This was important so that these activities could be then developed considering teachers' immediate classroom practice and the science topics they were teaching. This bespoke design is one feature of the professional learning activities designed in this study.

This public school in Male', established as a primary school (grades 1 to 7) in 1996 was converted into a grades 1 to10 school in 2011.The school had a total student population of 1428 in 2018, of which 160 students were in grade 6. This is a two-session school and grade 6 attends the morning session (6:55am to 11:30pm). There are five 35-minute periods allocated for science per week, with two periods doubled-up on once single day, to provide time for science learning activities, such as experimenting and investigating.

Classrooms have open windows, but on a typical sunny day, despite the 3 or 4 ceiling-fans and 2 or 3 complimentary wall-fans, it can get quite hot and stuffy inside these classes. Most classes have a group-seating arrangement with wooden desks and plastic chairs. In addition to a whiteboard, each classroom is equipped with a computer system, a multimedia projector fixed to the ceiling and (intermittent) Wi-Fi connection. As each classroom is shared with the lower primary grades in the afternoon, they have heavily and colourfully decorated walls, typical of lower primary classrooms, which to me sometimes was a bit distracting.

Science lessons are conducted in these classrooms, but for activity-led lessons, called as 'science experiments', the science laboratory is used. The laboratory has limited resources such as chemicals and glassware. The laboratory is staffed with a lab-technician whose responsibility is to prepare materials for the experiment set-ups as requested by the teachers. Unlike the classroom set-up the laboratory has a traditional seating arrangement of four by eight seats with an aisle in the middle (see Figure below). In the image I have pointed some teaching and learning features of this laboratory-set up.

Figure 7.2 Description of School D.

Before going into the field, I accessed the school's planning documents, namely the scheme of work for the academic year. The scheme of work is a detailed break-down of the sequence of topics into daily lessons, identifying the teaching activities and the associated assessment methods. Using this document, I established how and where the professional learning activities could be embedded around the daily teaching demands of the participating teachers. Further, **I expanded the documents to detail out *the teaching and learning activities*, *identifying the SPS* in these lessons so that we could address those needs during our co-planning for lessons in the professional learning activities.** To illustrate how school-based considerations were made in the design, Figure 7.3 presents how one topic from the scheme of work was expanded. Through such planning and designing consideration, the flexibility and bespoke nature of the professional learning was initiated, setting a precedent for collective ownership of the learning and the activities themselves.

How the unit *Water* was before

Science UNIT PLAN FIRST TERM GR 6

UNIT	TOPIC	SUB TOPIC	WEEK	PERIOD	ACTIVITIES	OUTCOME	KEY COMPETENCIES
11	Water	11.1 Water Quality	9 (11/3 to 15/3)	5	Activity 11.1 Water quality Search internet why Maldives is facing water crisis	EB 3.3: Researches the availability of water and the impact of human activities on the quality of water WS3.1 Takes care of themselves, others and respects others viewpoints	Water is the origin of all life and how it is highlighted in Islam
		11.2 Properties of water	10 (18/3 to 22/3)	5	Seeing a video Activity 11.2 Making fog in a jar	EB3.4 Recognizes the properties of water and make it an essential component of the Earth system WS2.1 Conducts simple investigations	There is scope for making decisions that reflect social responsibility

This plan was expanded to incorporate science process skills into these lessons so that we can see how science process skills can be explicitly focussed in the lesson planning and this in turn can also provide impetus for the professional learning activities (purpose of which was exploring science process skills pedagogies)

Wk	Lesson no	Science Process Skills emphasised
9	1	Focus on skills of • **observation** (through water maps or the fresh water availability demo) • **inferring** when discussing the implications of the fresh water available
	2	Focus on skills of **communicating** on importance of maintaining quality of water
10	1 -3	**Focus on skills of** • **Investigations**
	4 5	Focus on skills of • **observation** • **inferring**

Figure 7.3 Working with the Scheme of Work (Unit Plan).

It bears mentioning that during the implementation of these plans and activities, the plan was further modified and adjusted. Numerous unprecedented, systemic matters arose during the period of the professional learning engagement. As discussed in Chapter 4, I was aware that public schools in Maldives are often bombarded with sudden policy changes and so I worked to make flexible plans. In the next section I discuss some of these implementation details with regard to the professional learning.

Section 7.2 The professional learning activities

The basis for deciding the six different activities that comprised the TPL engagement in this study was presented in earlier in this chapter. In this section, I present these six activities, identifying their design features, how they worked in the overall professional learning engagement, and, where relevant, my roles (as researcher and professional development provider) in enacting these activities. These findings are important because they indicate what forms of professional learning are possible and available for generalist primary teachers in developing their pedagogical praxis.

As discussed in Chapter 3, professional learning is shaped by individual, collective, and contextual features. It was also argued that TPL should consider how the different elements of learning such as formal/informal, planned/unplanned, structured/unstructured and product/processual come about in combinations rather as mutually exclusive elements. For this reason, in the next section I explain the purpose, design and implementation for each of the different professional learning activity, highlighting how each of the above-mentioned elements were encompassed in these activities. Most of these activities were planned in clusters, as cycles that I go on to explain. In presenting the findings, relevant data from co-planned/co-developed resources (such as worksheets), individual and group interviews and discussions (such as reflection dialogues), and classroom observation notes are used to illustrate the main ideas.

7.2.1 Co-developing teaching resources

The purpose of co-developing teaching resources was to facilitate teacher’s familiarisation to curriculum prescriptions by exemplifying possible ways to translate these prescriptions into their classroom lesson planning. Furthermore, it was highlighted in Chapter 4 that a common practice in Maldivian schools is sharing one lesson plan per lesson across the grade, where individual teachers do not get much opportunity to contribute to its planning. As such, in this study, I wanted to explore the learning associating with co-developing resources together, where all teachers involved have the opportunity to have input into these resources, which creates opportunities to expand individual teacher's pedagogical praxis.

The design of this professional learning activity considered opportunities where co-development can be possible. As discussed in Chapter 4, in Maldivian schools, planning is mostly done in the fortnightly subject coordination meetings, often held after school. These meetings are normally administrative, with the grade leading teacher in charge; she lists the topics/lessons for the next fortnight for each subject, informing teachers of any administrative matters and co-curricular activities that are coming up. However, because this is a place where all the teachers are present, professional learning activities could be incorporated this meeting space. For the bespoke professional learning engagement, I requested these meetings be used to discuss, plan, and develop our professional learning activities. Using this fortnightly meeting platform would provide continuity for this activity, which is essential in the learning process.

In developing these resources, as the learning facilitator (and the researcher), I was often the one to offer and recommend alternative sequences for teaching some units, so that teachers (and students) would get more interaction with investigation-based lessons during the professional learning engagement. This way, I could also maximise my data collection time with the teachers as well.

When co-developing of the resources, I initially had to offer suggestions and teaching resources with a SPS focus. Sometimes, I would present the participants with various options for classroom activities and discuss what was feasible; if resources were unavailable, we discussed means for improvisation. At the beginning of the learning engagement, the teachers' suggestions for modifications were limited to administrative and organisational matters, commenting on aspects such as reducing the font size of an activity sheet or providing some space on the worksheet for students to write. However, once teachers started trialling out the science-investigation-based lessons, they could offer constructive suggestions on how some of the SPS are more relevant than others and they were able to reflect on how we could better design the next cycles of our lessons. Appendix A.12 provides further evidence on how our SIBA of students' worksheet template evolved through such suggestions and Appendix 11 provides samples of our co-planned lesson plans.

There were also instances where teachers shared with me some of the resources they had developed. They would request my input; my suggestions focussed on the explicit incorporation of SPS in these activities. Figure 7.4 below shows an example of teacher-developed activity and my recommendations for it. I have annotated on the figure how my input was on focussing on the SPS. The fortnightly meetings were not always a possible place for these group activities, so we had six of our research related meetings in the fortnightly meetings and five additional meetings.

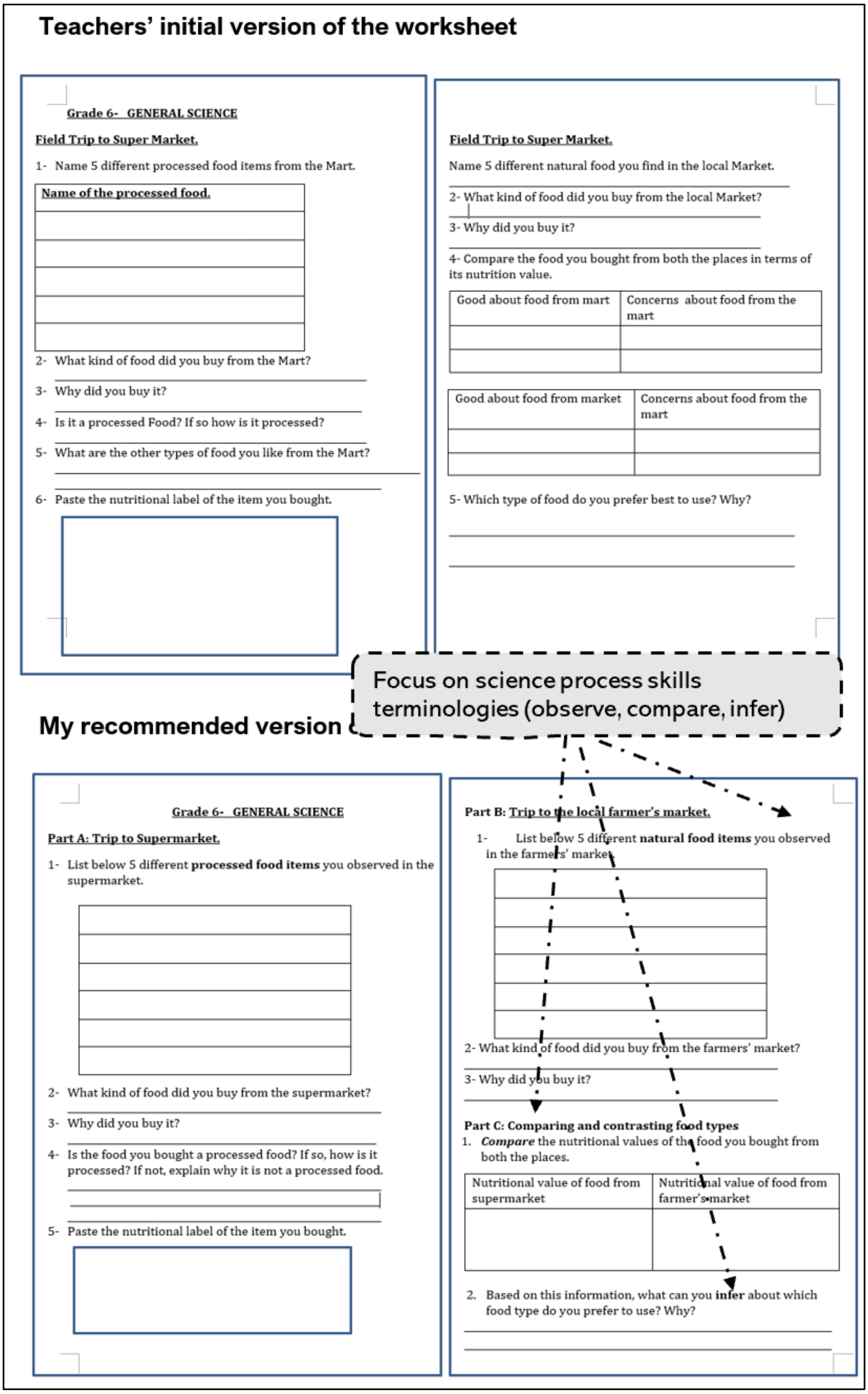


Figure 7.4 An example of teacher developed activity & recommendations.

When **reflecting** on how the activity in Figure 7.4 was implemented, it is evident that co-planning resources did not unfold as collaboratively as I had planned. I had assumed that all the teachers would have equal contributions and offer constructive suggestions to our co-developed resources. In this instance, it was evident that **collaboration was interpreted as *participation*** in these activities, demonstrated by their physical presence. However, with all the attempts in collaboratively co-planning these resources, what is evident is that teachers were not used to such collaborative co-planning and they did not feel comfortable nor confident to do so. It may be **because collaborative, co-planning practices are not norm in the Maldivian schools, but through scaffolded mentoring, guidance, and experience in offering co-planning lessons and resources, teachers can learn to collaboratively co-plan.** Further, teachers are willing to offer suggestions if those suggestions are collegially valued by their teacher communities.

7.2.2 Reflecting on practice and learning

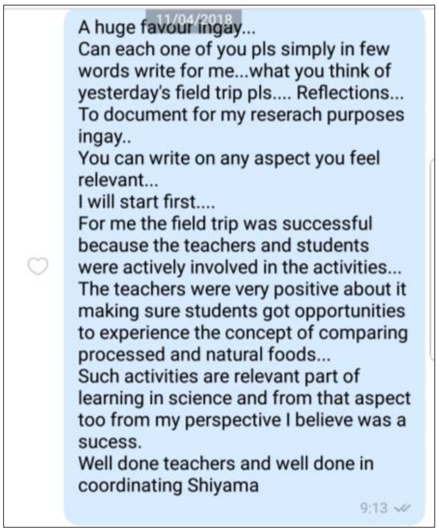
The purpose of incorporating reflection as part of the learning activity was to reflect on practice and learning; this step is critical for professional development and learning (Dogan, Yurtseven, & Tatık, 2019). It serves to connect teachers' learning to their practice and provides continuity and meaning to both the learning and practice. As discussed in Chapter 3, the process of reflections facilitates learning as a conscious, self-directed, and active engagement.

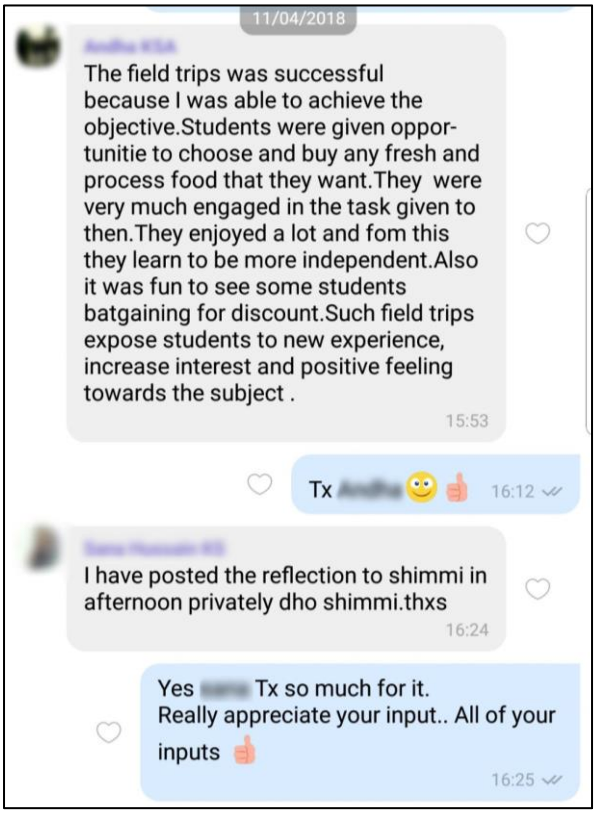
The design and implementation of these reflection activities considered individual reflection and group reflections. Individual reflections were important to trace individual teachers' learning while group reflection activities were to explore the collective learning. The individual reflections were either as post-lesson reflections or individual reflection meetings (data collection method of individual interviews). The group reflections were part of the fortnightly planning meetings (discussed above) or the research-dedicated group meetings. There is great importance for *group* reflection on practice rather than using only solo reflection, and so this activity was incorporated into most of our interactions, with a focus that increased as the professional learning engagement progressed. I had planned most of these reflections to be either oral or written.

In practice, most reflective dialogue took place in our meetings (individual and group). However, I also discovered the advantages and disadvantages of using online chatgroups for reflections. As previously mentioned, in my first meeting with the teachers, the leading teacher created a Viber chat group for us to communicate. With its popularity in the Maldives as a platform to communicate both formally and informally, I decided to use it to prompt teachers for reflections. After the development of our second co-developed lesson (a fieldtrip to the local market), I sent a request to the chatgroup that each teacher produce a written reflection. Interestingly, of the four teachers, three responded to this request on Viber. One replied to the group chat while the other two replied privately to me. See Figure 7.5 for screenshots of this Viber group conversation.

The Viber chat on my request for reflecting on our fieldtrip. To show by example, I reflected on the lesson first.

My request **Teachers' responses**





**ingay* is a casual-chatty term used in Divehi directly translated into 'you-know' or 'okay', but in the first instance used here, it is synonymous to 'please'.

Figure 7.5 Screenshots of our reflective dialogue on Viber.

This example indicated aspects of teachers' comfort with reflection. Firstly, there is potential for using online chat groups for reflective dialogue and some teachers prefer it over physical meetings. Second, though group reflections are ideal for collective growth of the teachers, some teachers hold their own individual reasons and prefer to reflect individually. With these different preferences, I maintained all individual and group reflections as spoken face-to-face meetings, though for following-up on learning goals, I requested teachers to write their reflections.

In considering how reflections supports teachers' professional learning and its place in the overall engagement, two things could be ascertained. **Firstly, teachers were not initially comfortable with reflecting on their practice**. This can be attributed to how little teachers are given opportunity to reflect in practice combined with the competitive performative practices ingrained in the Maldivian school-cultures (see Chapter 4); traditional formalistic pedagogies do not require reflective practices. **Secondly, over time, teachers were able to develop their reflective practice, implying that reflective practice *can* be developed through sustained use, focus, and encouragement**.

7.2.3 Classroom observations

The purpose of classroom observations as a professional learning activity is to record classroom teaching for feedback (from peers and the professional development provider) and facilitate teachers' reflection on their teaching (for example, Cochran-Smith & Lytle, 1999; Girvan, Conneely, & Tangney, 2016). Through multiple classroom observations, teachers can receive a series of opportunities to experiment with their learning and so they can attempt continuity in their practice and engage with opportunities to reflect in adapting their SPS pedagogies.

In **the design** of the classroom observation, it is recommended that observer and teacher engage in a pre-lesson discussion and post-lesson discussion/reflection, so that both will have a common understanding of what is being taught, how it is taught, and what aspects of the lesson will be the focus for feedback (Ambross et al., 2014). The focus of the observations was to be decided by the teacher to encourage teachers to lead the direction of these observations; for our observations, it was ideal that the teacher choose an area of their SPS pedagogies. I developed a classroom observation protocol (see Appendix 8) and peer-observation guide (see Appendix A.18) and to help with record keeping around how teachers were implementing these skills. Further, because I had initially considered teachers to observe their peers, this observation guide was meant to support such peer-observations.

This activity was the most challenging for **implementation** since scheduling researcher observation lessons was quite difficult with constant changes to schedules. Scheduling peer observation lessons were also difficult. These difficulties, together with the time constraints experienced by me as the researcher and teachers in their daily school activities, meant that only one instance of peer observation was possible, with Dheena observing Dhalia. Implications for this peer observations are discussed in the next chapter. Further, finding time for dedicated pre-observation discussion was difficult; I would get only a few words with the teachers just before they started the lesson, often while they are inside the classroom, settling the students. Similarly, for post-observation reflections, the plan was for teachers to both individually and collectively reflect on the lessons. However, post-observation discussion often could not happen immediately after the lesson, and often not even on the same day. In most lessons, post-observation discussions were done in groups. Table 7.2 provides the details of these observed lessons and how the pre/post lesson discussions took place.

Table 7.2 Details of the lessons observed

Cycle	Topic of lesson observed	Pre-lesson mode	Post-lesson mode
1	Investigating Photosynthesis (28/02/2018)		formal and in the group
2	Field Trip: Food in our Markets (Processed food vs Natural/organic Food) (10/04/2018)	Individual and informal (via Viber)	
3	Investigating weathering (07/05/2018)		formal and in the group
4	Investigating properties of water (surface tension) (25/06/2018)	Individual and formal	
5	Observing the water cycle (Making rain in a beaker) (03/07/2018)		formal and in the group
6	Observing evaporation of water (04/07/2018)		formal and in the group
7	Investigating soil porosity (09/07/2018)	Individual and formal	

During classroom observations I took notes on how teachers focussed on the SPS and in particular how the science-investigation-based lesson was being adapted by the teacher; I also took note of how students reacted to this pedagogy.

Often in the pre-lesson discussion, I would ask the teacher what particular skill she wanted for the focus, if any.

To illustrate, in Figure 7.6, I provide a lesson observation notes from Dhalia's lesson where she wanted me to focus on how she was teaching the skills of 'making predictions' and 'identifying variables', within the overall investigation procedure. When **considering how this activity** helped in teachers' learning, these observations were instrumental in getting teachers to engage in reflective discussion; the observations also provided continuity in their learning as well as the pedagogies we were exploring. The fact that peer observations were not possible can be attributed scheduling difficulties with busy teachers, but it also possibly can indicate that **teachers were uncomfortable in having a peer observe their class because of the fear associated with being judged**. Such behaviour is **emblematic in performative school cultures where classroom observations are often associated with teacher appraisals rather than collegial support**.

Dhaliya's lesson investigating factors that affect weathering – 7 May 2018

Pre-lesson

We had few minutes to just go through Dhaliya's plans. She showed me her lesson plan. it was simply her version of the students' worksheet. She said having worked out the 'answers' on how to complete the activity sheet gives her an idea of how to conduct the lesson. So, I told her I will observe how she instructed on the science process skills, connected it to each other and then integrate the content to the investigation method. She agreed but asked to check on skill so **predicting** and **identifying variables**.

Notes from the lesson

What I observed	My thoughts and reflections (*to follow in the post-lesson discussion*)
Predicting skills was discussed for over 5 minutes. Mentioned it as important, being like hypothesis and how scientists work too. Students were very interested in this aspect, writing it down and responding to her questions well.	All is good but this might have to be balanced with other skills… Students' responses are positive implying they are engaging and learning these skills better.
Identifying Variables Explicitly discussed independent, dependent and constant/controlled variables. Stress on these names and gave time to students to write these aspects in the initial discussion of the planning of the discussion that was done whole class	Very happy with how she emphasized on variables… this was in our planning discussion I had heavily stressed on the importance of labelling the skills and explaining it to the students. Need to ask her how she felt about this part. I saw confidence in how she explained this skill. This came from heavy planning too as is evident on her improvised lesson plan, where she had written these aspects down

Post-lesson

I got few minutes with her before she walked to her next class and told her I was very impressed with her planning and how she had handled the instructions for these skills. She laughed and said she had checked the text book, other resources to prepare for this lesson and made sure had 'read up on the meanings' of these skills

Post-lesson group discussion (8 May 2018)

Main point discussed:

- All teachers suggested that the procedure for the investigations still needs minor modifications…making it more student-friendly, they suggested.
- Also teachers now believes that if we as a group had actually tried this investigation, we could have avoided the issues we had with the resources.
- So, we all agreed before the next investigation lesson, I would do a demonstration lesson with the teachers…(ok, now going as I had planned)

Figure 7.6 Lesson observation notes from Dhalia's lesson.

7.2.4 Individual goal setting

The purpose of goal-setting activities were to make the learning meaningful, bespoke and empowering for the teachers (Stoll et al., 2012) through identifying their learning goals, engaging in follow-up and then reflecting on these goals. These goals were meant to be short-term, practical, and relevant to the teachers' learning needs. Such goal settings are important for the individual meaning-making of learning and enable learners to navigate their own learning trajectories. Further, as discussed in Chapters 3 and 5, these teachers are frustrated by externally-mandated learning goals. By setting personal goals in addition to the collective objectives of the professional learning engagement, teachers (and I) would be able to differentiate teachers' professional learnings (Timperley et al., 2007).

In **designing** these activities, it was important that along with the teachers' learning goals, I made my own goals for my role as the professional learning facilitator. My goals were set to support teachers' work towards their goal. Through such support, there would be differentiated support and scaffolding for the teachers to achieve their individual goals within the collective professional learning engagement. Goal-setting promotes collegiality and is a participatory research method characteristic of my broader research methodology of participatory-teacher-research (Cochran-Smith & Lytle, 1999). As discussed in Chapter 5, at the centre of this methodology is making teachers co-researchers, meaning that the learning activities have to promote teachers' autonomy and agency (Cochran-Smith & Lytle, 1999; Lytle, 1997). As part of the goal setting, a follow-up activity was also designed, ideally a fortnight after the goals were set. I had planned for multiple opportunities for such goal setting and follow-up exercises, but I did not initially decide on the frequency, wanting to keep it flexible.

The implementing of this activity was quite different than I had planned. Firstly, although I had planned to start goal-setting activities earlier on in our engagement, once I started working with the teachers, I recognised the difference in investment that teachers paid to this professional development project; they further differed in how they conceptualised their role in this engagement. Statements such as 'Shimmi, tell me what to do, I will do it and show you that in my classroom', demonstrated that teachers understood the purpose of this learning engagement in a manner different from my conceptualisation of it as collaborative and meaningful for the teachers.

For these reasons, I introduced the goal setting activity towards the end of the second month into our professional learning engagement. This timing was important because, at that stage, we had collectively explored some science-investigation-based lessons and our group dynamic was starting to become productive. These initial activities had given teachers opportunities to experience the *hows* and *whats* of the pedagogies that we were exploring. As such, the time investment enabled us to establish a collective understanding of the concepts we were exploring in the activities (Evans, 2002). This particular timing was also critical for developing teachers' trust in me both as researcher and professional development provider.

Once the teachers set their goals, I discussed with them how they would like me to support them in achieving those goals; I then set my associated goals (see Appendix A.7 for template used). For most, the first goals were around their own learning, while the second set of goals were focussed on their student's learning. To illustrate Table 7.3, provides Dhaha's first and second learning goals and my associated goal to help her. **In goal setting, all the teachers focussed on how they will teach, instruct, and follow-up on the SPS in their classrooms**.

Table 7.3 A sample of teacher's learning goals.

	Teachers' goal	My supporting goal/role
Goal one	When doing activity 6.3 (**investigating weathering**) I want to be able to focus mostly on skills such as **observations** and **inferring**.	Discuss the lesson before and after to see how these skills will be and have been done and through this provide the support needed
Goal two	Carry out experiment in small groups	Plan investigation-based lesson together to incorporate small groups.

It was difficult to find time for follow-up on these goals, but there were occasions when it was successful. In the first follow-up activity, we used the group meeting to collectively reflect on individual goals. Providing this reflection time as part of the professional learning activities was crucial because it enabled the teachers to see the continuity in their pedagogical learning and practice and the goals helped them to ground these learnings. Often times, during these reflections, I **played the role of an empathetic listener, a 'critical friend'** (Costa & Kallick, 1993) to teachers, encouraging them to engage in professional pedagogical dialogue in reviewing their classroom practice. To illustrate, when I asked teachers to reflect on a lesson, their reply would often be a brief, 'it was ok', 'yea I think it went well', or the popular 'the lesson objectives were achieved'. Sometimes the focus would be on the students and the task, with teachers saying, 'I think students completed the activities. Thus, with my observation notes and the learning goals, I prompted Dhalia to reflect more on her teaching practices and connect her learning to her learning goals. Such prompting helped in directing teachers' reflection towards their practice, as evident in the dialogue with Dhalia below.

Me:	So how was the lesson (*after lesson on investigating weathering*)?
Dhalia:	The students took so long than I planned, to count the water drops! I was so focussed on time and making sure they finished the investigations.
Me:	Overall, how did the investigation go in terms of SPS?
Dhalia:	I think it was okay, plus under this topic this term there are more investigations we are doing so I can connect them to each other.
Me:	That is great you are seeing that connection and, in the lesson, I observed you were explicit about the process skills and explaining them to the students, and it made me really happy to see it.
Dhalia:	Oh Yes, I can now do that in my lessons because I am aware of it and I can. I always feel that I don't know science background before, but now that I am in this with you, I am learning these skills and I think the more I do, I can myself learn to apply these skills in my own teaching because I understand them. I think students can even see that. Also, because we have these investigations planned, I am more motivated to go and read up on these things at home because I am interested to learn more.

(Translated Dhalia Individual Interview, 26 June 2018)

Similar encouragements supported other teachers' constructive reflection on their goals.

Overall, the goal-setting exercise made a change in giving us all (teachers and researcher) a sense of where the professional engagement was going as well as steering its directions for each teacher individually. In having two goal-setting activities and two-follow-up activities, the act of articulating these goals were helpful. Although goal setting and follow-up are part of good teaching practices, **the heavy administrative demands on these teachers leaves no time for setting such learning trajectories**. However, this professional learning engagement shows how easily this goal-setting activity can be incorporated into teachers' routines and can be possible by support and encouragement from their peers and leading teachers.

7.2.5 Demonstration lessons

The purpose of these demonstration lessons was to provide teachers opportunities to experience learning SPS through the science-investigation-based approach. Research by Radford (1998) pointed out when teachers are allowed to experience the same content, methods, and activities that their students would expect to learn in schools, teachers are better prepared to help students become active, engaged learners.

In designing these demonstration lessons, the theoretical and practical perspective of SPS pedagogies could be highlighted. They were structured so teachers could first act as students who would experience the lesson that I provided. Following this, teachers would reflect on the how the skills were emphasised in the lesson, and how those skills connected with each other and the science content. While developing the content of these lessons, it was crucial that we explore topics that the teachers were planning to teach (preferably within a week), so that teachers could immediately apply their learning to their classroom practice. Similar to most of the activities in this professional engagement, I had planned that four such demonstration lessons would be possible, starting one month into the learning engagement.

At the beginning of the professional learning engagement, I made several attempts to **implement** these demonstration lessons; however, despite my (gentle) suggestions, we could not move ahead. Along with challenges because of the teachers' busy schedules, I also felt that teachers needed time to try the pedagogies and identify their learning needs in order for them to *want* a demonstration lesson. As such, there were two demonstration lessons conducted, with the first taking place four months into the engagement. This timing worked out so that the demonstration lesson coincided with teachers' research lessons (discussed below). Experiencing the lesson prior to their actual teaching gave them an opportunity to better prepare the lesson and gain confidence in the content and the SPS they were teaching.

Each demonstration lesson lasted two hours and consisted of two sessions. In the first hour, I conduced the lesson for the teachers (the PowerPoint slides used are in Appendix A.13), providing a coaching experience for the teachers from an 'external expert'. The second hour explored how the SPS were emphasised in the lesson. Focus was on the lesson sequence and the explicitness of giving instructions regarding the SPS and checking for students' progress and learning of these skills. Based on the teachers' level of understanding of the science content, I would spend considerable time on discussing the science behind the concepts of the lesson as well.

The **value of this as a professional learning activity** was evident in teachers' positive comments and deeper engagement with the science-investigation-based approach, following these demonstration lessons. I felt the first **demonstration lesson was a pivotal moment in our learning engagement**. Following the first demonstration lesson, Dhalia, who was teaching science for the first time, expressed how much she had learnt about the skills as well as the science content. In fact, this learning motivated her lesson planning for the actual lesson she taught. Similarly, Dheena stated that:

> *…mihaaru eba ingay aslu mi skills thah…ingigen kiyvadhey iru eba apply ves kurevey…(then bodah thorough vefa confident ves vey eba ekkoh aharun teachers mi lessons thah try kureema.*
>
> **Translation** I am learning these skills more now …I feel like am teaching this knowing them so I can apply it better, am more thorough and confident because we all of us teachers have tried these lessons together now.
>
> (Dhaha Individual Interview, 26 June 2018)

7.2.6 Teacher led classroom-based research

The purpose of having a teacher-led classroom-research activity as part of this learning engagement was to empower teachers in their learning and give them an opportunity to experience how their learning impacts students' learning. There is ample research which argues that when teachers gather evidence from their practice and students' learning, it provides powerful professional learning experiences (Bishop & Denley, 2007; Cochran-Smith & Lytle, 1992, 1993, 2014). Further, as discussed in Chapter 3, such teacher-initiated classroom-research is also powerful in promoting practices of democratic teacher professionalism where teachers' evidence-based pedagogical decisions, their agency, and voice in such decisions come to the forefront of teachers' pedagogical praxis.

These research lessons were initially designed flexibly as activities where teachers could do when they felt comfortable and able. In designing, teachers were provided with a structure to develop the research lesson (Appendix A.15). The rationale was for each teacher to conduct a small action-research inquiry into their classroom teaching, which was in some way designed around SPS, so, in the process, teachers could make meaning of their learning and connect their practice to our collective pedagogical inquiry. As teachers' research-lessons involved gathering evidence from teachers' practice and from students, this evidence was used to inform both teacher practice and provide an indirect way to gauge how students were reacting to the science-investigation-based lessons for teaching SPS. Further, in the design, I considered that these research activities would require scaffolding. However, because of the subjective nature of how teachers would *seek* scaffolding, the manner in which I supported each teacher was decided during the implementation of this activity.

In the implementation of the classroom-research, it was important that teachers had built their trust in me as a researcher and professional development facilitator; thus, this activity was introduced following the first demonstration lesson. As these action-research techniques were part of individual learning, teachers were invited on the research template to decide their research questions and design the inquiry. I had given the template to the teachers for their consideration; I asked them to complete it if possible so we could discuss it. However, due to a shortage of time, we instead did the planning discussion in individual meetings and group meetings. Figure 7.7 shows the research inquiry for each of the four teachers mapped into the central purpose of this study.

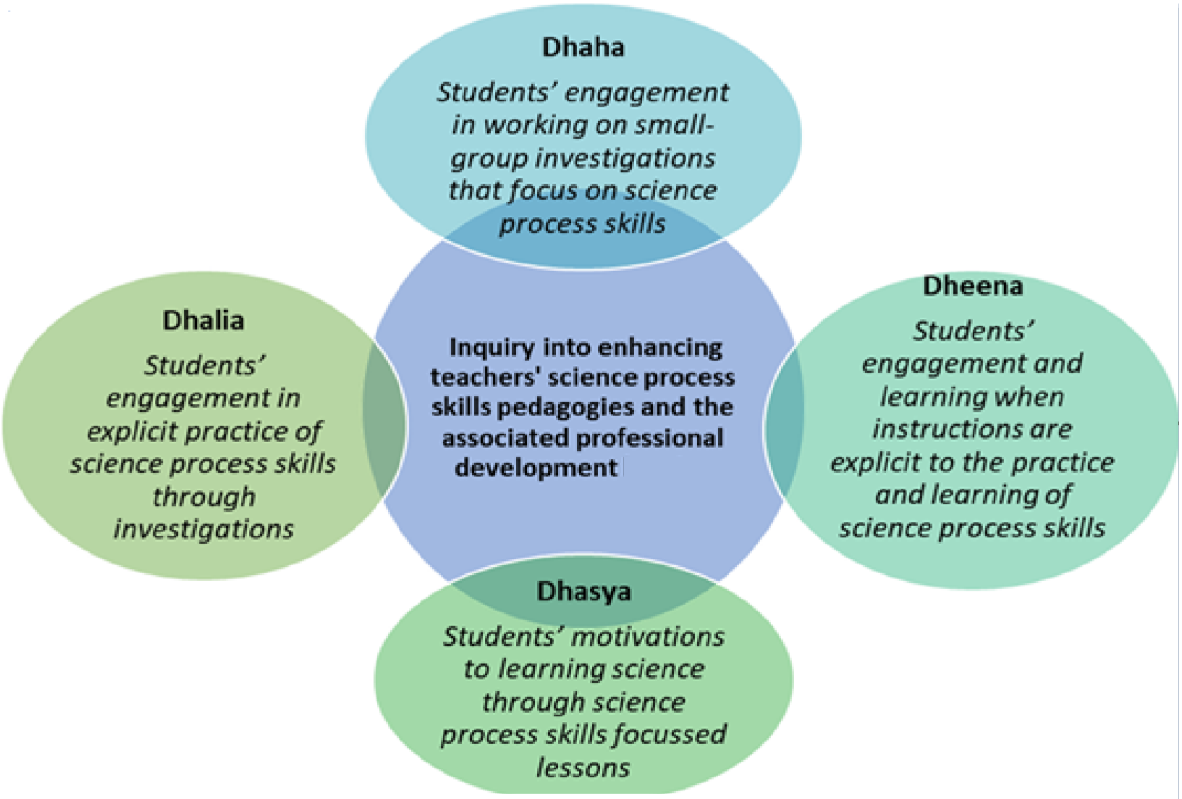


Figure 7.7 How teachers' individual research nested within this research.

As identified in the design of this activity, **teachers' inquiry focussed on students' learning.** I suggested possible data collection methods once the teachers offered what evidence would inform answers for their research questions. Similarly, the data analysis approach for each teacher was dependent on the nature of the data they collected. Table 7.4 summarises the four teachers' data collection approaches and the forms of data analysis used.

Table 7.4 Teachers' data collection methods and analysis approaches for their classroom-research.

	Data collection method	Data analysis approach
Dhaha	Students' comments/feedback (24 students) after two lessons (*lesson one - teacher-led demonstration of the skills, lesson two- had students conducting most of these skills in small groups.*)	Compared comments of every student across both lessons to see the change in their reactions from lesson one to lesson two (themes identified include 'science is fun when I do it with my friends')
Dhalia	Students' comments after the lesson; Dheena's notes from her peer observation of the lesson	Themes were identified (e.g.: Doing science makes students more 'into' science); Dheena noted students' reactions and engagement in the lesson.
Dheena	Three students' work samples of their completed investigation report	Analysing the SPS demonstrated in the report
Dhasya	A pre-post set close-ended and open-ended questions	Descriptive statistics on how students' reactions changed from before to after the lesson.

Although unintended, all of the teachers decided the same lesson (investigating surface tension) as their research lesson and this commonality provided interesting ground for me to compare teachers' practice, learning, and their use of evidence in informing their pedagogical praxis. These aspects are discussed in the next chapter.

Overall, this set of activities was interesting for two reasons. Firstly, for me as the researcher and professional development provider, **it was interesting to see and gather evidence on how teachers were connecting their learning to their pedagogical praxis, and then to students' learning.** Further, these mini-research studies provided us for the collective inquiry evidence on how students were reacting to the pedagogies, further encouraging teachers to use SIBA lessons in their science teaching. Oftentimes, teachers do not get time to reflect on their students' responses and work samples to recalibrate their pedagogies, and this professional learning activity provided them time to do so, which was valuable, especially since they were trialling out a pedagogy different to their norms. For example, Dhalia was uncomfortable in teaching science because of her limited conceptual knowledge but seeing her students' positive reactions to her teaching (through students' comments and Dheena's lesson observation notes) boosted her confidence. This is evident in the following excerpt from their conversation:

> Dhalia: Students were enjoying the lesson…and that makes me very happy (seeing this). Students were interested in the task.
>
> Dheena: Actually, it (the lesson) was very good, (the students) were so focussed on accurately doing the measurement… resting her head comfortably on the table as she was counting the drops.
>
> There were also discussions going in the class…students were loudly counting 1,2, 3… and shouting out across to other groups their (surprised) results and asking for others. That shows motivation/excitement. They were surprised that it was very different that they had predicted…I think they were learning that…
>
> Dhalia: This is a hands-on science lesson we are doing after a long time away from lab-oriented science lessons. So, students were very excited and motivated [in this lesson]. So that made me happy about this lesson, and I think I am enjoying.
>
> (Translated Dhalia & Dheena Reflective Discussion with Peers, 2 August 2018)

In the next chapter I present findings on how all these activities complemented each teachers' learning and development of their pedagogical palette in unique and different ways throughout the professional learning engagement.

Section 7.3 Responding to unplanned learning opportunities

A powerful learning activity that I had not planned for transpired whilst I was in the field. This was **co-teaching**. Mentoring and coaching were considered, but I did not expect to be co-teaching any of the teachers' lessons. I had initially planned to be a non-participant observer in all the lessons I observed. When a teacher first requested that I co-teach during the first set of classroom observations, I was surprised and unsure how to respond because I had not planned for it in the research nor in the actual professional learning engagement itself. Yet my guiding principle was that the study is participatory, so all levels of participation from me and teachers should be welcome. I noted the following in my diary after the first co-teaching:

> I have not co-taught with a teacher before, this is very interesting. Quite a different experience than sitting at the back of the class with my 'teacher educator' hat on. I think this way I can be the teachers' partner in teaching, offer more support, scaffold the instruction. I can even engage with the students too. I can also offer corrections when teachers misinterpret or miss certain instructions. But I do not want to take over the lesson though.

(Research Journal, 28 February 2018)

Co-teaching is a strong aspect of pre-service teacher training; in PD activities, co-teaching has on occasions been used but the reporting is limited. For example, Haymore-Sandholtz (2002), Ronfeldt, Farmer, McQueen, and Grissom (2015), and Butler, Lauscher, Jarvis-Selinger, and Beckingham (2004) have described co-teaching briefly in the design of their respective PD programmes, but all of these researchers failed to further describe its effects (if any) on teachers' professional learning itself. In particular, Bantwini (2012) reported primary teachers expressing a need for co-teaching as a form of professional development support.

Most of the instances where I joined the teacher occurred when I was with Dhalia and Dhasya. At times, they requested this involvement because they wanted to learn how to deliver the SPS-focussed instructions to the students, or simply because they were unsure about integrating the content of the lesson with the SPS. There were also times when I decided to gently step in so as to reiterate teachers' instructions or to remind the students of safety instructions. I felt that these **co-teaching experiences provided the teachers some scaffolding to adopt the**

investigation-based science teaching into their teaching pedagogies, evident in that teachers' requests for me to co-teach slowly faded over time. The co-teaching also provided me (as the researcher) valuable depth into these lessons and the teachers' pedagogic repertoires.

Section 7.4 Implementing professional learning

I was aware that all of these activities required a lot of the teachers' time and effort. I was also aware that, as discussed in Chapter 4, within the daily school schedules for these teachers, finding time for these activities would be challenging. I did not want to impose these activities, and yet I wanted teachers to engage in them meaningfully. This approach required me to be very **flexible with my scheduling**, and still constantly reminding teachers about these activities. For example, in the first week when I met with the teachers to share the purpose of this research, I shared a scheduling template and requested that teachers to suggest times for the activities, based on their timetables. I had hoped for a term-long plan so that I could better plan the professional learning activities. I discovered this approach to planning did not work. Upon follow-up, Dheena replied they cannot do such planning as the school schedule keeps changing[48], and suggested instead that I offer a plan rather than 'making the teachers do it'. Due to the administrative demands placed on teachers by the school and the MoE, in addition to other systemic factors (for example, shorter school hours due to Ramadan), these **plans were constantly changing.** This challenge was resolved by only planning a day or two in advance.

In the implementation of the professional learning activities, a cyclical pattern for the activities was followed: planning, implementation (and classroom observation), and reflecting. There was a total of **seven cycles of activities** (Figure 7.8) where all the teachers participated. At the beginning of the professional learning engagement, these cycles took longer to achieve. In each of these cycles, my collective and individual input as a professional learning provider varied based on teachers' collective and individual needs.

[48] This was the most frustrating stage for me both as a researcher and professional learning facilitator.

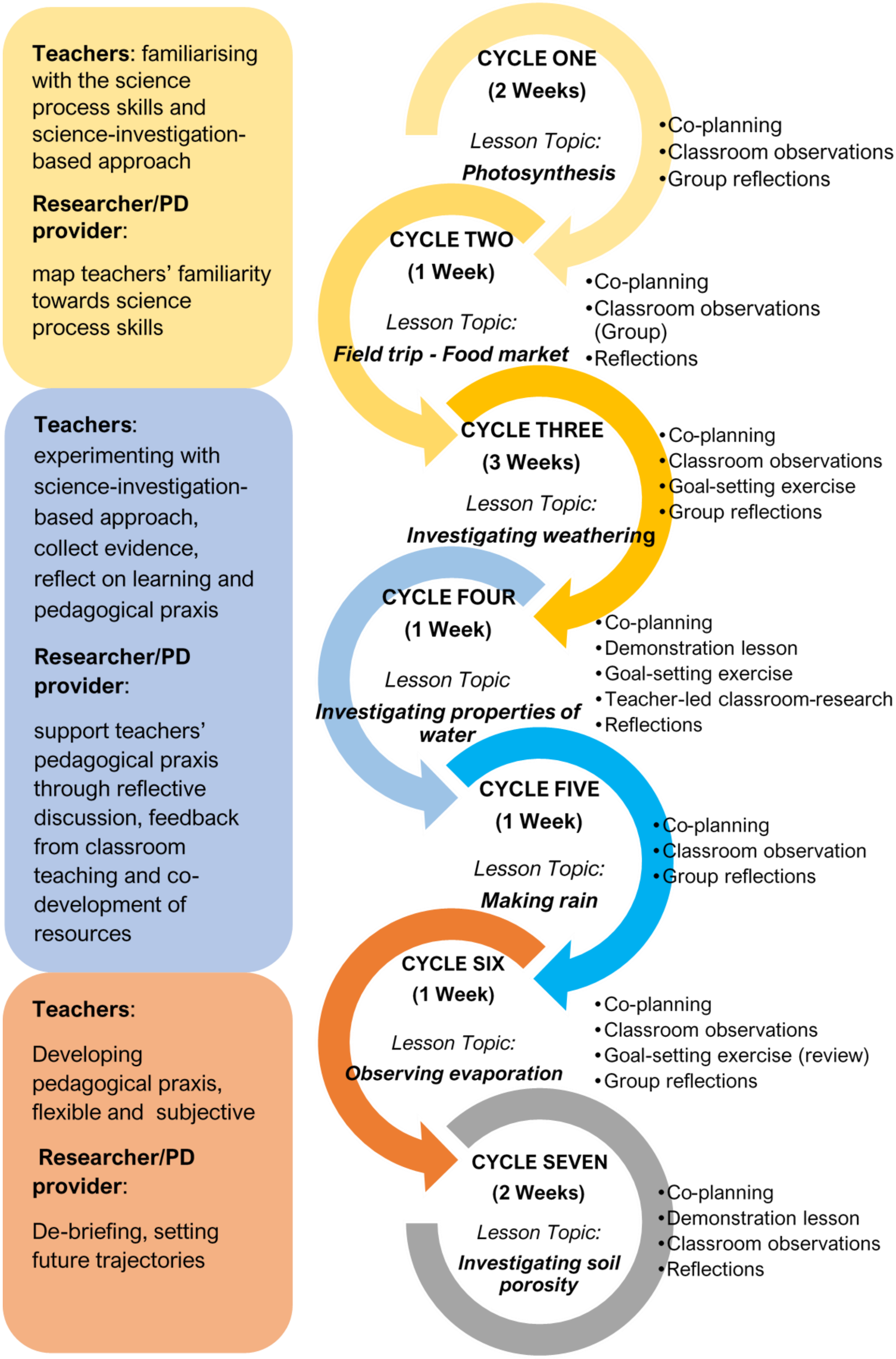


Figure 7.8 The cycle of professional learning activities.

Further, for research purposes, we (teachers and I) entered each cycle with a different purpose for both the professional learning and the research, as explained here:

Cycle 1. The purpose of this cycle was to explore teachers' familiarity with integrating the SPS into their classroom instructions, explanations, and classroom-talk. My aim was ascertaining teachers' familiarity with understanding and teaching these skills.

Cycle 2. This cycle was initially unplanned for. Similar to the first cycle, this cycle was focussed on establishing teachers' familiarity with SPS.

Cycle 3. This cycle was focussed on working with teachers for their individual, short term goal-setting and follow-up. At this point, the individual learning was beginning and so my input for each teacher was different based on their learning needs. Classroom observations in this cycle helped me further understand how the teachers were individually planning and implementing SPS in their classrooms.

Cycle 4. The third cycle involved individual classroom research. I provided structured support at the first demonstration lesson, prior their lessons.

Cycle 5. The purpose of this cycle for the research was to allow teachers to develop their autonomy in the approach that they chose for integrating SPS into their teaching. There was minimal input from me in co-planning.

Cycle 6. Similar to Cycle five, in this cycle teachers had more in planning the lesson. Such autonomy allowed me to understand the individual and subjective nature of the teacher's learning and pedagogical praxis.

Cycle 7. The last cycle was used to explore teachers' individual growth in their pedagogical praxis in using the investigation-based approach to teach SPS. For research purposes, the cycle offered the final set of activities in the professional engagement, and so it was also used to evaluate teachers' learning and trajectories for their pedagogical praxis.

In the implementation process, I identified key elements of the professional learning engagement that seemed to be working for the teachers in developing their pedagogies for SPS. These features are mapped below in Table 7.5 in relation to the features discussed in in Chapter 3 (Table 3.1), expanding on how these features are implemented, observed, and realised in contributing to teachers' professional learning.

Table 7.5 Implications of different features of the professional learning activities.

Features suggested in Chapter 3	Meaning of the feature to this professional learning engagement
Collaborative and collegial	**Collaboration and collegiality are often interpreted as participation**
Enhancing pedagogical praxis	This is possible, but **requires scaffolding, structuring** and **mentoring**
Ongoing and sustained	This is **crucial and teachers prefer both face-to-face interactions and online interactions** to keep the learning momentum going.
Reflecting on existing practice	**Constant opportunities to reflect**, individually and in groups promote reflective practice and learning
Learning is social	Social learning is critical for teachers, for their **development and belonging to the community of science teachers**
Ownership of learning Action-research	Action-research style classroom-based research **facilitates teachers to gather evidence on their pedagogical praxis** and students' learning.

7.4.1 Reflecting on my dual roles

My role as the researcher and professional learning facilitator was reflected in the professional learning activities. Both of my two roles were important: as a researcher, my primary focus was gathering evidence for the study, and as a professional learning facilitator, my primary focus was the quality of the learning experience that I could create for the teachers. Most times, these two roles complemented each other; however, when they did not, I considered teachers' welfare as my priority. For example, teachers would reflect on their lessons during informal conversations when I wouldn't have my audio recorder or notebook handy to record; even doing so (taking notes or pulling out the recorded) might have broken the flow of their reflections. At these times, I would save my researcher hat for when I could get home and record these conversations from my memory in my research journal.

Conclusion

This chapter has presented findings relevant to the designing and implementing of the bespoke TPL engagement. These findings highlight the need for contextual sensitivities and contingencies in such learning engagements. The individual activities designed and implemented in this learning engagement were presented, and I highlighted how each was modified in response to the context.

In summary, the key features of the professional learning activities that worked include the following: multiple opportunities for individual and collective meaning-making from professional learning; curriculum familiarisation through co-developing curriculum resources and collective experimentation; collecting evidence from classroom practice through teacher-research; supportive and flexible collegial support; development of science content knowledge of the process skills together with their classroom pedagogies; and most importantly, flexibility in the implementation and practice of the TPL activities. In the next section, I report the individual and collective teacher professional learning journeys to demonstrate how each of them engaged with and made meaning from this professional learning engagement.

Chapter 8. Pedagogical Praxis and Teacher Professional Learning

> Story is the very stuff of teaching, the landscape within which we live as teachers and researchers, and within which the work of teachers can be seen as making sense.
>
> (Elbaz, 1991, p. 3)

Introduction

In this chapter, I present findings from Phase Two, which explored a group of generalist primary teachers' pedagogical praxis for science process skills (SPS) associated with engaging in a professional learning inquiry. In Section 8.1, I present narratives as stories of these teachers' learning journeys over the course the professional learning inquiry. These narratives are (re)constructed from multiple sources of data, extracting out individual teachers' learning that was embedded in the collective professional learning engagement. Section 8.2 presents themes across these narratives which highlight teachers' collective pedagogical evolution and professional learning experiences. In Section 8.3, through a reflexive lens for my involvement in the professional learning inquiry as the learning facilitator and researcher, I identify some challenges for a pedagogical, inquiry-based teacher professional learning (TPL).

Section 8.1 Narratives of professional learning through pedagogical inquiry

In this section, the four teachers' professional learning journeys are narrated. A brief overview of these teachers' backgrounds has been presented in Section 5.3.2. Each of these narratives is composed to present a brief summary of the learning journey for the four individual teachers in Phase Two of this study. These narratives are illustrated by data from teachers' interviews, classroom observations and associated photos[49], together with our co-developed resources. It is important to note here these narrations are constructions from my perspective and engagement with the teachers, both as a researcher and professional learning facilitator. To convey these stories more authentically, some of the quotes used in the stories are first presented in Divehi, followed by the English translation. In Section 5.6, I have discussed this decision in detail.

8.1.1 Dhaha

Dhaha has been teaching grade 5 for her entire 22-year teaching career and, for the first time in 2018, she began teaching grade 6. When the school re-allocated grade 5 teachers to move to grade 6 in 2018, Dhaha was assigned to teach grade 6 in the morning session of the school, meaning she could spend her evenings with her family. She taught science, social studies, and physical and health education (theory), creative arts for her class and another grade 6 class, and three other grade 8 classes with a total of 21 periods per week[50].

Dhaha was a participant from Phase One of this study. Her emphasis in the interview was strongly focussed on how SPS make learning fun and enjoyable and

[49] The school often put photos of students working on their Facebook page, and most of these were gathered from there, though I assisted them in capturing them during my classroom observation time.

[50] Each period is 35 minutes.

promoted students' interest in learning science. According to her, it was such positive student learning experiences of SPS and her own motivation to try innovative teaching that had prompted her to participate in the professional learning engagement.

Discovering the joys in teaching SPS.

In our first goal-setting meeting[51], Dhaha set herself the following learning goal to be followed-up within a fortnight:

> When doing Activity 6.3 (**investigating weathering**) I want to be able to focus mostly on skills such as **observations** and **inferring**.

(Dhaha Goal Setting Notes, 19 April 2018)

However, due to various school-level interruptions (discussed in Section 8.3) this cycle took longer; by the time I observed her teaching of Activity 6.3, Dhaha's teaching focus had moved to the SPS for 'making predictions', 'measuring' and 'identifying variables', demonstrating her growth in understanding and application of SPS. I noted the following whilst observing her classroom teaching in how I saw her teaching of these skills.

Predicting:	Got individual students to think about what they expect will happen and to write them down. This focus was good
Measuring:	She emphasized the measuring skills by highlighting the units (ml) that being used to measure the volumes (water and vinegar)
Identifying variables:	Was discussed, but the focus provided in the table (worksheet) was not made clear…I think maybe need elaboration

(Dhaha Lesson Observation Notes, 7 May 2018)

My impression of this lesson which I discussed with Dhaha was that while she was explicitly focussed on the skills within the science-investigation, the skills

[51] By then we had implemented two cycles of professional learning activities.

seemed to be disjointed. I also **noted that basic skills of prediction and measuring** was stronger in her instruction than the integrated skill of identifying variables. In Chapter 6, similar practices were identified to be common amongst generalist primary teachers.

However, during the lesson reflection discussion, Dhaha demonstrated how her **pedagogical decision making is connected to her classroom realties**. She indicated that she focussed on few skills because this was first time where she was explicitly focusing on the skills in her classroom instructions and explanations and highlighting their importance in science. Such a practice **demonstrates Dhaha's abilities to scaffold her students' learning** of SPS. Dhaha also provided feedback to our collective co-planned science-investigation, identifying how we had missed some practical classroom realities in our planning process. Her classroom reflections demonstrate how her pedagogical choices were motivated by students' enjoyment in learning science, expressing her satisfaction in seeing the active nature of their learning and how they could relate their observation skills with the initial predictions. Such a reflective dialogue demonstrated Dhaha's developing **pedagogical praxis and confidence in how her conceptual and procedural understanding of SPS were developing through the TPL engagement**.

Evidencing from classroom-research.

Dhaha's classroom-research was led by the inquiry question '*How do students' engagement and interest in the science lessons change when they do small group (2-3) investigations*?' This inquiry was significant in evidencing **how students responded to different approaches of teaching science-investigations.**

At the end of two science-investigation lessons, Dhaha requested that her students write how they felt in these lessons. The first lesson was designed as a group-based investigation while the second was a teacher-led demonstration of a science investigation. Dhaha gathered comments and feedback from her 24 students. As I observed these lessons, I noticed how excited students were when asked to provide feedback. Their reactions signify **how teachers can involve students in classroom pedagogical decisions**.

To analyse these students' comments, we mapped each students' response to both the lessons. Figure 8.1 provides an excerpt from her comparison table. Dhaha observed how students preferred to work in small groups for science-investigations, and how **group settings were significant for students' social relationships**.

	Small-group managed investigation	**Whole-class teacher-led demonstration**
		
ST22	The experiment was fun and entertaining. Doing the experiment in the science lab is a fun thing. We learnt somethings from doing the experiment.	This experiment **was a bit boring** since we had to watch the teacher do it. It is good to do these experiments …But I hope the next experiment we can do it ourselves.
ST5	I enjoyed it. It's fun when you can pair up with your friends and do it.	It was fun, but not as fun as doing it individually.

Figure 8.1 Dhaha's classroom-research lesson data excerpts.

Professional learning for developing SPS.

Dhaha came to this research with several years of science teaching experience, so she was comfortable in using the curriculum as a guide and was able to interpret the curriculum outcomes in her lesson. Based on data from Phase One, and the initial lesson observed, I could see that Dhaha focussed heavily and exclusively on observation skills, limiting her focus on other SPS, although the investigation-based approach had those other skills. Though she was comfortable with the content of the science lessons, she was not as comfortable in explicitly using the SPS in her classroom.

She expressed in the second interview that she has started to notice an improvement in her teaching based on the professional learning engagement. She reflected back and stated that she used to think that skills such as hypothesizing were not important nor possible within the primary science teaching. She further expressed that although the curriculum prescribes it, investigation-based, hands-on, skills-focussed lessons were not a priority in her past science teaching because of limited time and her assumption that they were not relevant for teaching science. However, with this professional learning, she **started to realise the place for these skills in science teaching** as important and key to learning science. She herself was learning the skills and thus better applying them in her teaching. In our final interview, Dhaha stated:

> *Kureega aharun nahadhan kudhin lavva prediction ey …kihiney hey mivanee visnaashey ehen ves aslu nubunan...kurevey kanneygey kudakoh orally, but not as written work… mihaaru mi gothah hadhaathee style miothy mulhin badhalu vefa, mihaaru aharun experiment hadha konmey faharaku mi gendhanee mi sequence ga nu.....future ga ves gendheyveyne aslu...beynun kuran ves*
>
> **Translation**: Before we did not get students to make prediction. Did not even ask [students] what will happen, or what do you think will happen…maybe we did orally, a bit, but never as written work. Now we have started doing this way, so our teaching style is changed. Now every time we do experiments/investigations we will be following this sequence. In the future too we can and want to too.

(Dhaha Individual Interview, 31 July 2018)

Her familiarity with the content and the curriculum outcomes meant that **once she was familiar with the science-investigation-based lesson sequence, she was comfortable to adjust the investigation sequence based on her students' learning**. Dhaha's changes in her pedagogical praxis was also evident in how she structured student activities. Prior to the professional learning engagement, in a typical lesson, she would focus mostly on the skills of observation. However, due to her learning from the professional activities, her **vocabulary for SPS grew, both in her classroom teaching and in the written work she assigned to her students**. To illustrate, Figure 8.2 compares two of Dhaha's approach to teaching SPS before and after the learning engagement. The photo from 'before' is a sample of student's work showing the heavy focus on observations through a rigid structure for investigation, while the photo from 'after' is the photo of the work she assigned her students showing her use of SPS in a more open investigation approach where she is explicit about skills such as hypothesizing, observing, and designing investigations. Annotations on the figure are provided, explaining these changes.

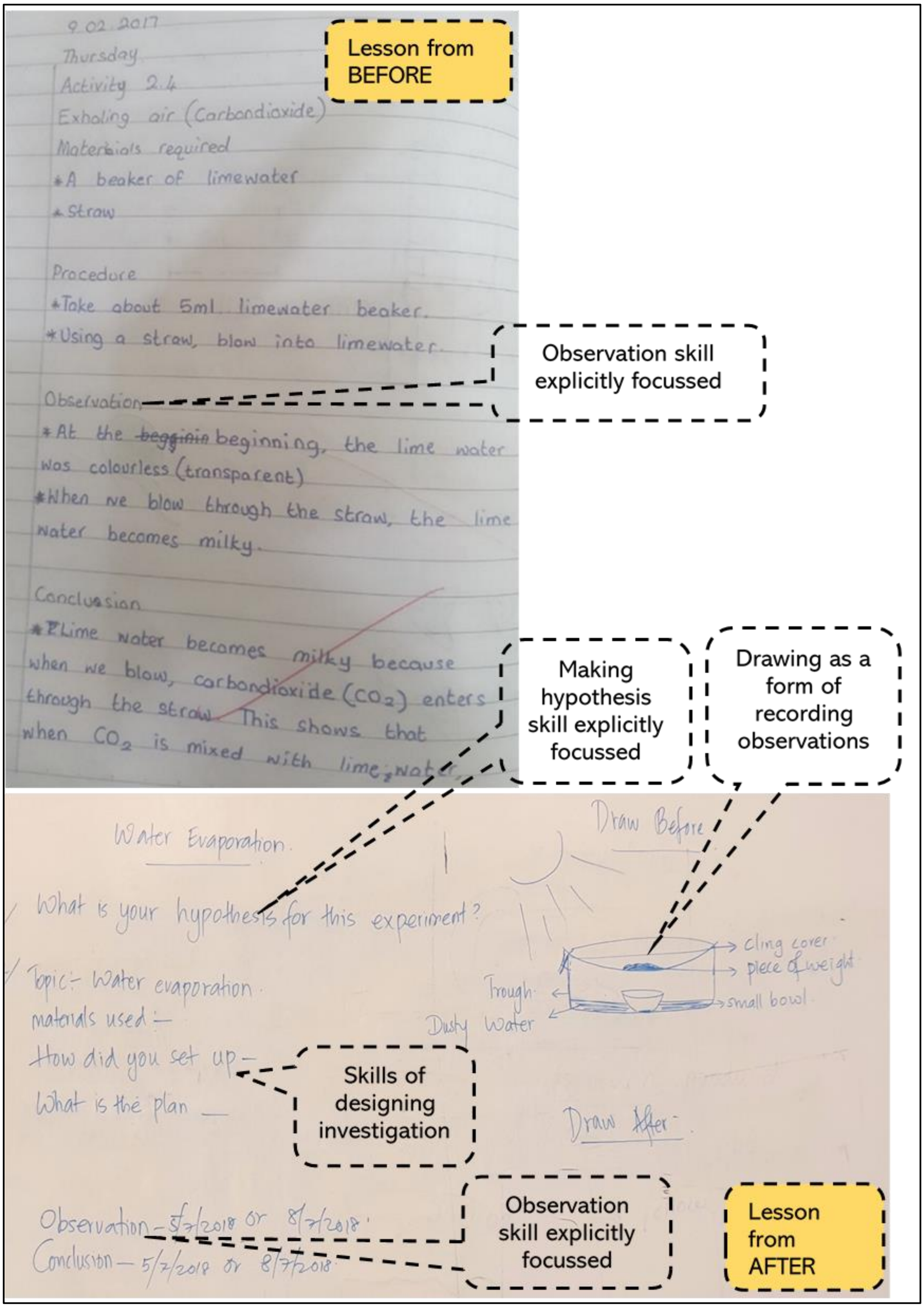


Figure 8.2 Dhaha's students' work from before and after.

8.1.2 Dhalia

Dhalia has been a primary teacher for 15 years and her area of teaching and training is predominantly social sciences. She coordinates Social Studies for grades 6 and 7. As Dhalia was new to teaching science, she was feeling unprepared to teach it, mostly because of her perceived lack of science content knowledge beyond her GCSE studies. This limited knowledge made her feel unprepared for science lessons and overcoming this feeling of unpreparedness was her main motivation to participate in this research. Dhalia's teaching load of 20 periods per week included teaching science and social studies for her grade 6 class and social studies for a grade 7 class. Whilst engaging in the activities for this research, she was enrolled in a part-time B.Ed. programme to upgrade her qualifications.

Dhalia was not a Phase One participant, so before the first interview, I met her to explain my research. In this meeting, Dhalia's excitement and **expectations for the professional learning to support her science pedagogies** were clear:

> *Asluga beynumee science aa gulhun huri eki topics thakun aharumen kiyavaadhey goi [Shimmi] balaa eyah improvement ey gennaney gotheh hoadha dhinun. Aharumen mi kiyavadheynee rangalhah tho bala…skills thah kiyavaadhenee rangalhatho balaa, ithurah help ey ve dheveyney dho …ideas thakeh kuriah gendhaaney gotheh dhee…ei kanneygey beynun vane*
>
> **Translation:** What I really want is (you) to see how we are teaching these science topics and skills and find out ways to help us improve these. See that if we are teaching these [content and skills] correctly, help/support us more. Provide us with ideas and ways in how we can move forward.

(Dhalia Individual Interview, 22 February 2018)

Interestingly, for Dhalia the idea of teaching the **'right' material in the 'correct' way was a significant aspect that drove her motivation for professional learning**. Dhalia's motivation for learning can explained by Maldivian performative school culture (see Chapter 4), where the product of teaching is more important than the process of learning.

Refocussing the purpose of professional learning.

Dhalia's first set of learning goals were established to develop how she taught the skills of observation and classification. After the learning cycle, she reflected:

> The goal was not achieved. Need to give more time for observations so that students will be able to see the changes and relate to what they have learnt from weathering.
>
> (Dhalia Teacher Reflection Notes, 09 May 2018)

Following this reflection, **Dhalia re-calibrated her own learning goal towards student learning and on the collective skills of investigation** rather than one individual skill, as demonstrated by her second learning goal:

> Conduct more investigations in small groups focussing more on process skills. This (would) creates more interest in students.
>
> (Dhalia Teacher Reflection Notes, 26 June 2018)

Similar to Dhaha, Dhalia connected her learning goals to student's learning, demonstrating that her motivation for professional learning comes from a desire to make her science lessons interesting to her students. I observed that **this refocussing made her less anxious** about her science content knowledge and encouraged her to individually put more effort into her lesson planning. For Dhalia, gauging her learning based on students' learning (or reactions to the lesson) was an integral part of her teaching and learning philosophy. I understood this gauging was also her way of validating her own learning.

Evidencing from classroom-research.

Dhalia chose to research to see '*How does students' engagement increase (change) when we do science investigations focussing on SPS and do so in small groups?*'. She decided to collect evidence from students' feedback notes and peer-observation feedback. Her colleague Dheena observed the lesson together with me to provide the feedback. For students' feedback, she collected eight students' written responses after the lesson.

To analyse students' data, Dhalia and I categorised the comments into themes (see Table 8.1 for an excerpt). These comments were further converged through lesson observation feedback Dheena and I provided Dhalia. Dheena and I had observed a high level of student engagement where students were enjoying learning and talking about the science concepts and skills they were experiencing. Thus, Dhalia could conclude that she had evidence to say that her **students enjoyed learning science when in small-groups because they get to do science-investigation-based activities**.

Table 8.1 Themes from Dhalia's research lesson.

Categories/themes	Examples from data
Science is fun when students get to do experiments and investigations	*Today's investigation was fun, and I love investigation because it is very informative* *It is more fun to do investigations and exepriments because we will be able to find out things by doing it in real life. I like to do it in pairs or on or own so that we can see it better*
Doing science investigations have made the students more 'into' science	*I absolutely love experiments because I am really into science and I feel like it is the best choice which I learn a lot from it*
Students like/prefer doing hands-on work in science because for them such learning is meaningful and of value than the conventional teaching methods	*I absolutely love the science experiments we condut in the lab compared to the works we do in our exercise book* *I would really like to have other investigation because we get to learn a lot from experiments*

Learning from practice and experience.

At the beginning of this research, in my observations of Dhalia's classroom teaching, I noticed a strong content-oriented, product-focussed style of teaching. This focus was common across teachers in Phase One (see Chapter 6). In our first interview, she admitted this limited focus on skills in her teaching.

> *Anehen mi stress ey aslu nukurevey me process skills ekey kiyaafa..ehen ey word ey use ey nukurevey kanneygey ey lesson thakuga..ekamu lesson thakuga observe kohfa noonee investigate kohffa hunnaney… aharun ey*

> *words use kuran mee observation ey mee conclusion ey ekamu mee science process skills thikudhigai ashaganan ..ehen kiyaafa ey nubuneyvei huredhaaney…ekamu ey words aharun lesson thakuga, activity thaguga beynun kuran kanneygey*
>
> **Translation**: [We] don't stress that these skills are science process skills. But I think we have lessons and activities that focus on investigation and observation and we mention these words in the lessons [as teaching instructions], but I don't think we convey to the students that that these are important SPS.

(Dhalia Individual Interview, 19 April 2018)

One reason for an implicit focus on these skills in Dhalia's teaching can be attributed to her limited science content knowledge and an associated low competency in teaching science. She expressed that teaching science was not enjoyable because of these difficulties. While this professional learning may not have completely attended to this matter, **the collective exploration of pedagogy with the associated content knowledge had helped develop her science teaching and thus teaching science became enjoyable**.

Another possible reason was an unawareness of the investigation-approach to incorporate the SPS and how to integrate it with the lesson content. From the initial observations of Dhalia' class I understood that **both students and teachers lacked a clear understanding and communication of the SPS, and the value of these skills in teaching science tends to be overlooked**. However, through the professional learning activities Dhalia had managed to implement the SIBA template with an explicit focus on the individual skills.

In her final interview[52], Dhalia reflected with a specific reference to the final SIBA lesson[53] she conducted, 'focussing on SPS in my lessons has made me more interested in science (both the teaching and learning of it)'. At the end of the

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[52] 5 August 2018

[53] 9 July 2018

professional learning engagement, Dhalia concluded that she feels more confident in teaching science and the investigation-based approach to science lessons was something she wants and plans to continue. **Having the investigation template and practicing it in the classroom has given her tools that she can easily adapt and use in her future science lessons**.

Comparing two of her lesson in this learning engagement (Table 8.2) demonstrates Dhalia's growth in her pedagogical praxis. In her lesson on June[54], she did not spend time on explaining the skills, but she strictly followed the procedures of the investigation template. However, in the lesson on July which followed professional development support from me and her peers, she managed to explicitly focus on the skills in her classroom instructions and integrate them in her explanation and discussion of the lesson. In the latter lesson, her explanation of the skills was more interactive and detailed with a stronger emphasis on skills for identifying variables and using vocabulary appropriate for explaining these skills. Table 8.2 below shows comparison of these two lessons; the comparison is constructed from my lesson observation notes for these two lessons. In both lessons, her focus on making students 'write down' variables (identified in green in the Table 8.2) is interesting because this feature is a typical performative practice that was highlighted in Chapter 6. Evidently, **with more practice and reflection in conducting investigation-based lessons, Dhalia was learning the skills and enabling herself to better implement them in her pedagogies (though to a limited extent).**

[54] This was from cycle four – on investigating properties of water.

Table 8.2 Comparison of two of Dhalia's lesson

Note: T refers to Dhalia and St refers to students

Lesson in June on surface tension of water	**Lesson in July on soil properties – water retention**
T: Now for **the fair test** part, we have to write what are we changing here. 'change one thing'…What are we changing here? St:(in audible answer from the students) T: Huh? Side of the coin is what we are changing. When we are doing this investigation, we are changing the side of the coin, okay Under change one thing, in your worksheet we will be writing side of the coin as the thing that we are changing. **Measure** or **observe** one thing, what are we measuring? It is the number of water drops. So we write that under the next column. This is what we are measuring. When we are putting drops, we will keep all other things the same. Like the height of the drops (height from which is dropped), and when you press the pipette press it in the same level, *ehaa barakah ves noon ehaa madakun ves noon* (translation: not too hard not too softly) . So you write height and pressure as the things you will keep the same. All of you please write this.	B: For the **fair test**...look at the table of variables provided. Change one thing, that is the **independent variable**. So what are we changing? St: Water, Soil B: Yes see we are changing the type of water, so in that column that is what you write, what we change, the types of soil and write the different types of the soil. Are we changing anything else in the **investigation**? St: it is soil T: So, it is soil only, and usually we have one independent variable. Next, is identifying the thing that you **measure** or **observe**. This is the **dependent variable** What is that you are measuring? St: Amount of water. T: It is the amount of water retained. Remember that is what we are measuring here. Next, keeping all the other things the same, this is the called **constant variables**. In the last column in the table you write. So what are the things we are keeping the same here? For example, we have 100ml of water for each type of soil. So same amount of water. Write that down. Even though we are using different types of soil, we are taking the same amount of soil of each. So we have same amount of water and same amount of soil. Also we are going to check within a given amount for each soil to drain the water. So same amount of time is also another one. These are the **constant variables** for this investigation (goes on to review these three variables again)

8.1.3 Dheena

Dheena has been a primary teacher for over 20 years. Although trained as a generalist teacher, she is responsible for teaching English, science, social studies, mathematics, physical education, and practical arts. Her strength is in teaching science and she prefers teaching science over the other subjects. This strength has enabled her to work as the grade-level subject coordinator for the past five years. Over the professional engagement period, her teaching load changed from 20 to 25 periods per week, with the additional 5 periods allocated to her due staff shortages. Dheena was also enrolled in a masters' programme to update her qualifications.

I first met Dheena while she was doing her Bachelor of Education degree. She was also a participant in the Phase One of this study and had expressed her need for focussed professional learning support that she could improve her abilities in **planning and communicating about activities regarding these skills**.

Leading the professional learning activities.

Because of Dheena's **interest in teaching science, together with her leading role as the science coordinator, she was more actively and closely involved in co-developing the materials for our inquiry**, unlike the other participants. As discussed in Chapter 4, developing and disseminating teaching resources are often the responsibility of the subject coordinator, an arrangement common amongst generalist primary teachers in the Maldives. Thus, Dheena in her role of science coordinator lead the co-development activities. For example, she asked my suggestion on a summative assessment worksheet she had produced. I modified it to make the SPS more explicit on the sheet (see Appendix A.10), explaining to the group where these skills can be incorporated in the content. Another lesson where I provided feedback on an existing resource was discussed earlier in Section 7.3.1.

The photosynthesis investigation lesson template was one I offered first, and Dheena played a key role in providing input to the template, seen in her modifications to this template (see Appendix A.14, embedded in the observation notes) and the previously-mentioned assessment sheet. Further, for this lesson, because of time constraints, all teachers could not meet together before the lesson to discuss its implementation. Thus, Dheena offered to meet all the teachers without me and de-brief the teachers on the lesson procedure. She later expressed her frustration with the different levels of engagement from her peers during this explanation. Such comments demonstrate her **'evaluative' role as the science coordinator, which is often reflected in how she led the group-based professional learning activities**.

Taking control of professional learning.

Over the course of the professional learning engagement, I noticed that Dheena's **uptake of the pedagogic innovations even at the onset of the professional learning was impressive and can be attributed to her existing level of conceptual and procedural knowledge of SPS.**

Dheena is familiar with a variety of science teaching approaches such as problem-based-learning (PBL), and so she expressed her desire to try out this approach and set herself the leaning goals as:

> 1. Try-out a PBL based lesson on the topic of corals
> 2. Let students reflect on preventing damages done to coral reefs and protecting the living organisms in coral reefs
>
> (Dheena Goal Setting Notes, 23 April 2018)

However, due to the disruptions to the school by unexpected mandates from the MoE (elaborated in Section 8.3), Dheena was not able to implement the PBL lesson as she had planned, but still she reported on trying it to an extent in her lesson. As term two began, Dheena's teaching schedule changed to two grade 6 science classes since one of the teachers had quit. These extra lessons provided her more opportunities to experiment with the science-investigations-based teaching. **Together with her interest and experience in teaching science, these multiple opportunities gave her more time to reflect on her teaching as well as on the viability of the science-investigation based teaching**.

During the second interview[55], Dheena expressed that the level of support for her science teaching she was getting from these TPL activities, was very helpful and now she was **developing a clear idea of how the SPS could be incorporated** with an improved understanding of science investigations, highlighting how the collective exploration was also supporting the group learning.

> *Content aslu eba mihaaru ingen fashaifi ...like surface tension ves..bodah practically miharu eba dhasvey...kurin aslu mihen activities focus ey nukuran…abadhuves textbooks in use kurany… activites thah enmen ekkoh jesseema hurihaa teachers ah eba ingay mihaaru mi vaa goi, content kiyavaadheyney goi, aslu enmen ekkoh thibegen hadhaa goi discuss kuran eba jehey...aharun lava mihen hedheema enmenah ves faidha vey...lesson beleema ingeyney eyge kura faidhaa....kurin discuss nukoh, try nukoh hedhi lesson photosynthesis ga kiha thafaathu enemen hedhi goi.....skills focus ves neyngey eyru…dhen meegen mi ingay future ga aharunna ves migothah mikan kurevidhaaney kan*
>
> **Translation:** Before [I] was not familiar with the content, but I am getting familiar to it now, like that concept of 'surface tension', I did not know its application before. Now that we are doing it, I am learning it practically. We didn't focus on activities and skills before. We used only the students' textbooks for classroom activities, never made our own. Now that you are making us trail-out these investigations ourselves, facilitating discussions on how to teach these, it is highly beneficial for us…you too can see this in our classroom lessons. The first lesson we did with you on photosynthesis, we did without such discussions and it was a disaster because no one knew these skills so much and could not focus on them. Now this [referring to demonstration lessons] shows that that in the future we can carry on this way [explicitly focussing on SPS].
>
> (Dheena Individual Interview, 27 June 2018)

In our final interview[56] she reflected that in **using these SIBA lessons, she could also assess students' skills formatively** and such forms of assessments had great benefits for the disengaged students in her class as well: students' engagement could have perhaps improved with a better integrated science lessons

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[55] 27 June 2018.

[56] 2 August 2018.

where students were actively learning the science content. As discussed in Chapter 4, discipline and teacher-control are hallmark teaching styles commons in Maldivian classrooms. It seems that science **investigation lessons can not only improve student's engagement in learning but can also provide teachers some form of 'control' in the lesson**.

While teachers such as Dhaha and Dhalia connected their learning with students' learning, Dheena did so as well but with broader applications. Dheena, with her stronger science knowledge, reflected that she can now use her knowledge of different students' levels and styles of learning to better plan for her lessons and **differentiate her investigation-based lessons accordingly**. Again, such reflections demonstrate Dheena's leading role in professional learning in science as well in setting an example for her peers.

Evidencing from classroom-research.

Dheena's research lesson focussed on students' learning, with the research question:

> What happens to students' engagement (and learning) in my classroom when I use instructions (and teaching that are specific on science process skills) in teaching science topics?

Dheena decided to use evidence from students' worksheets to answer the research question. Her assumption was that students' engagement and learning can be demonstrated through their level of work completion. Dheena collected three students' work samples (see sample provided in Appendix 16) and we analysed them together to identify how the students have demonstrated the individual skills as evidence for their engagement and learning.

Dheena's key focus was on students' ability to perform the work within the lesson-time, and that they were able to 'correctly' relate the data to the concept of surface tension. For her, this implied a successful lesson. Table 8.3 provides our collective analysis of these work-samples, indicating students' learning and engagement of the SPS. In answering Dheena's question for the research lesson, this data showed us that **students were engaged and learning in lessons that are investigation-based.** In fact, Dheena pointed out that, unlike other typical science lessons, students completed the work within the lesson timing, and this is evidence of students' high interest and engagement in the lesson. Apart from this, I also noticed how Dheena has incorporated a variety of SPS in this lesson, a level accessible for her due to her science teaching experience.

Table 8.3 Analysis of how science process skills are presented through the students' work-samples.

Science process skill	How it is presented across the three samples	What it means for students' learning
Writing a research question	Were the same across the three samples.	As it was the same investigation students were doing, having the same question is reasonable. *This imply learning of this skill*
Hypothesizing	The prediction and associated hypotheses were different. E.g.: "It *will hold 7 drops because the surface area is small*". "The *water droplets will join because of surface tension*"	The range of difference in how students have hypothesized that they are thinking on their own and attempting scientific hypothesizing. *This imply learning of this skill*
Identifying variables	The way students have presented them in their work is different	The range in how students have written these variables show that they are thinking and learning this skill. *This imply learning of this skill*
Planning the procedure	Wide range in how students have written the procedure. Length varied from 31 words to 60 words.	The variety in how students have written the procedure show that they are learning this skill. *This imply learning of this skill*
Recording results (measuring)	Range of results presented.	Range of results imply students have measured, calculated and recorded the results well. *This imply learning of this skill*
Making a conclusion/ inferring	This is the same verbatim across the three	This has been recorded through heavy teacher-input. *This imply students have not been able to practise this skill independently*

A significant finding for me was that, Dheena has in fact facilitated the learning and application of most of these SPS for this task. However, in some skills such as inferring and making conclusion skills, she had heavily 'directed' students' responses on the worksheet, which she justified as her way of making sure all students 'got' the idea of the investigation 'correctly' and related surface tension as the property that they were learning. Such views again are emblematic of schools' performativity cultures (as discussed in Chapters 4 and 6).

Understanding pedagogies and flexibility in implementation.

At the end of the term, I could see that Dheena's teaching of SPS had evolved such that she could adjust the presentation and application of these skills in her teaching to suit the needs of the students. Dheena pointed-out her **ability to extend and apply her learning to other areas of the scheme of work** that has come about through focussed and guided exploration of these skills.

Dheena discussed how adjusting her process-skills-based teaching to the students' level and competence was important to her. **She adjusted the sequence rather than follow the standard inductive approach of science investigation**. In fact, throughout all the SIBA lessons that we trialed for this research, she adopted a 'backward approach' to our planned investigation sequence[57]. She had students directly conduct the data collection/experimentation, record the data, and then, based on that data, retrospectively identify the hypothesis and the variables of the investigation. Dheena pointed out that this way, students understand the hypothesis and the variables and can easily identify them.

> *Aslu is-fas kurema maa bodah ingey kudhinnah..ei kurin dhineema kudhinna activity nahadha aslu hypothesis ey hadhaakah neynge…adhi mi skills kiyava iru kudhin aa veem..next lesson soil investigation hadha iru I think they may be able to follow the set sequence*

[57] In the approach we planned we had the skills in the order; hypothesising, identifying variables, experimenting, observing/measuring, recording, inferring and making conclusions. Dheena got students to consider possible hypothesis in retrospect of the investigation, asking 'what could have our hypothesis been?'.

> **Translation**: Actually, the backward approach is more helpful for students in their understanding. It is because they are not familiar with making hypothesis, so without the activity they can't put it together. Because students are especially new to learning these skills. So, this backward approach is much useful. Maybe in the next investigation I might try the other way.

(Dheena Individual Interview, 26 June 2018)

Based on my observations of her classroom teaching and students' responses in the lesson, I could see the truth to that statement. This was an interesting observation and learning for me as it shows the level of flexibility that teachers can bring into their pedagogical praxis. Further, Dheena's learning was deeper and meaningful to the point that she expressed her desire to initiate a school-wide TPL programme for her peers in promoting science investigation-based approach to teach science. Through her role as the science coordinator, such an initiative would be a positive school-wide movement in incorporating SPS into science teaching pedagogies.

8.1.4 Dhasya

Dhasya has been a primary teacher for 20 years; she started her teaching career as a primary mathematics teacher. This year, though it was her first-time teaching grade 6, she was also co-leading[58] grade 6 mathematics subject coordination. This was also her first-year teaching science; she taught science, social studies, mathematics, and health and physical education (HPE) for her class, and also math for another year 6 class; she also filled in for HPE for a year 7 class. In total, she was teaching 26 periods.

[58] Together with the grade leading teacher (LT).

Like Dhalia, Dhasya did not participate in Phase One of this study, so I set up an initial introduction meeting. Similar to some of the Phase One participants' talking points, **Dhasya's discussion on her practice was theoretical and what 'good teaching' should be like.** When inquired about SPS teaching, she pointed out that because of resource limitations, she and her colleague are left with alternative ways to teach these skills.

Based on the first lesson I observed[59], I noticed that even though Dhasya knew the theoretical knowledge behind constructive pedagogies, she had difficulties in implementing them in her teaching. I observed that she constantly struggled to communicate in grammatically correct English. I**n classroom teaching such a language issue may not pose a huge problem if her science content knowledge was not limiting her explanations,** but in her case both, were limited and thus problematic. While observing one of her lessons, I made some notes (see Appendix A.14) on the abruptness of her skills-focussed instructions. During the post-lesson reflection, Dhasya defended this observation saying she personally felt confident in teaching these skills and believed that she had sufficient knowledge about these skills, and the only issue was a lack of time.

> I personally feel that I know how to teach everything in a skills-based manner…I have done primary teacher training plus middle school teacher training… so I can teach up to grade 7 all subjects (Divehi and *Qur'an* and all subjects). We did science experiments too….so that was not very difficult for me too…I did science in my secondary school, so it was not new to me… I thought this year in teaching science first time would be difficult, but it is easier than I thought…. But the issue is time…. I do enjoy teaching and am happy with how I am doing it

(Translated from Dhasya Individual Interview, 22 April2018)

Such a defensive line of talk can be attributed to her distrust in me as a researcher and how my involvement could impact her teaching.

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[59] 28 February 2018.

Evidencing professional learning through goal setting.

Dhasya chose her first set of learning goals focussing on the task of lesson planning. She wrote:

1. Discuss with other teachers before taking the lesson.
2. Reflect the skills before the lesson.
3. Collect all the necessary materials before the lesson
4. Carry out the activity the way I plan in the lesson

(Dhasya Goal Setting Notes, 23 April 2018)

After the learning cycle, Dhasya reported her success in achieving these goals. Her follow-up response reflected the goals, but in my own observation of the lesson, I could not agree that she had achieved those goals, so **we both had very different views of the same lesson.** It seemed that she assumed I was there to prove her wrong, and I was not there to support her professional learning. Based on these reflections, her second set of goals focussed on what she would do in the lesson implementation. They were

- Give more time for the students to the experiments
- Give more information and instructions before the experiments
- Discuss with other teachers how to conduct the lesson.

(Dhaha Goal Setting Notes, 23 May 2018)

In our reflection discussion when we revisited these goals, she reflected that in her teaching, she had focussed on predicting skills; the skills of identifying variables were not emphasised as much as planned. When inquired why, she **defended her teaching by pointing out the lack of lesson-time and limited preparation because of her busy schedule**. She further insisted that any issues in the lesson were not because she did not know the skills but were due to curriculum prescriptions. Such defensive line of talk **identifying external sources that limit her teaching tended to limit how she engaged in the professional learning activities.**

> *Your focus akee identifying variables kamah viyas aharun teaching ga ehen egothakah focus kohgen nugendhan....ei vaa gothakee,…aharun focus kuranee indicators only…if they achieve it, then ey nimuneenu... Indicators ga neendhey dho eythi identify kuraakah*
>
> **Translation**: Your focus maybe on [the skills of] identifying variables on our teaching, but in our teaching that's not a major focus because we follow the

indicators in the curriculum. If the indicators are achieved by the students, then it is done. These are not in the indicators.

(Dhasya Individual Interview, 3 July 2018)

In our final interview, when asked to reflect back on these challenges, she responded favourably, pointing out that **group planning helped her manage her classroom time when doing investigations.**

Me: *Time dhevunutha fahun lesson thakuga?*

Dhasya: *Aaan time dhevunu….ehen visnaigen gendhiyaeema… Planning ga ehen ready vefa otheema aslu faseyha vi… Migothahready vevueneema aslu varah faseyha…Ehenvey meethi kiyadheyn time libunu….aneykka varah kuda vaguthu kohlehy therey content cover kohlevey …*

Adhi time dhevuneema kudhin aslu varah interstest hure… kudhinge motivation ves anehkka kudhinnah complete kohlevey dho investigation ves aslu…adhi discuss kohllan vaguthu kolheh libihjeyya aslu varah rangalahu vaaney…

Translation:

Me: Did you manage to give more time [for instructing and conducting the experiments] in later lessons?

Dhasya: Yes, I managed to. This is because I had this in mind when planning. That is how we planned together. This way of planning [collectively trailing and discussing the lessons procedure in detail] made the implementation of lessons easy [for me]. So I managed to give that time for students. So, I was very well planned for today's lesson. So, in a shorter time I could cover the content even.

Also. Because I managed to give that time for the students they were very interested in the lesson. They were motivated too. They even completed the investigation worksheet…but if we got a bit more time in discussing the results it would have been even better.

(Dhasya Individual Interview, 31 July 2018)

For Dhasya, a great barrier to professional learning was a belief that she was doing well in her science teaching, so she seemed personally not invested in the professional learning activities. However, **the sustained activities and continuity**

on using the science-investigation-lessons made a positive impact on her pedagogical praxis.

Evidencing from classroom-research.

Dhasya expressed that she wanted to find out how students' motivation towards learning science changed after experiencing a science-investigation-based lesson. We developed a short set of pre/post questions to gather data from students. Figure 8.3 shows the tool she used.

SCIENCE INTEREST QUESTIONNAIRE

There are no correct answers for the following questions. You are being asked your opinion. Be as honest as you can. Tick the one that applies to you.

	Strongly agree	Agree	Disagree	Strongly Disagree
1. I like studying science				
2. I get to be part of the science lessons				
3. I enjoy studying science				
4. We do lot of fun activities/experiments in science class				
5. I like talking about the science we are learning				
6. Overall, what do you think of learning science?				

Figure 8.3 Dhasya's data collection template/form.

We applied descriptive statistics[60] to analyse data from 23 of her students. According our analysis, 50% of her students expressed that in science-investigation lessons, they could 'talk science' and 40% of the students' attitudes about science

[60] Dhasya demonstrated her quantitative data analysis skills here

'being fun' improved after the SIBA lesson. Similar positive findings were noticed in the response to open-ended question (Question 6 in Figure 8.3).

Further, Dhasya and I noted that almost all students identified science as 'fun'. These results are evidence towards the fact that **in activity-based lessons which especially utilise investigations done in the science laboratory, students are given opportunities to practise and do the science-based explorations and thus students' learning and excitement towards science increases.**

Needing to move beyond systemic challenges.

Dhasya constantly **expressed that her choice of pedagogies was determined by systemic issues** such as lack of classroom time or resources, or due to misbehaving students. She would point out either that she was 'doing it already' or that she is unable to implement because of time and resource issues. Despite these challenges, she identified that **students' positive reactions to her science-investigation-based lessons made a positive impact on her confidence and attitude.**

In our final interview Dhasya, expressed how these learnings will impact her future science teaching, identifying how her students reacted positively to these investigation-based lessons:

> *… mee aslu varah rangalhu gothen… Migotha lesson gendhevuneema kudhin aslu varah bodha learn kurey gina ehchehi… Mi gothah, prediction or hypothesis hadhaafa aslu experiment hedheema aslu varah dhasvey dho...amillah experience kohgen dho midhaskurane mi thafaathu vaakan…Mee aslu science kiyavadheyn jeheyney gothakee..me noon gothakah aslu science kiyvadheykah nuvaaney*
>
> **Translation**: This is a good way to teach science. When we teach science lessons this way students learn a lot. This way of doing experiment with prediction and hypothesising makes students learn a lot, as they are actually doing it…they do and learn the differences [between predictions and the data collected] and they learn the science concepts better. This is the actual/real way to teach science and we cannot teach science can any other way.

(Dhasya Individual Interview, 31 July 2018)

Throughout the professional learning period, Dhasya consistently pointed out that the lack of preparation time was a strong challenge that she (and other science teachers) experienced; other teachers who pointed this out were able to see beyond this unsolvable matter and were ready to find and invest time for their professional learning. Dhasya, however, came back to this issue in almost every discussion. I interpreted this as a lack of motivation for her professional learning and disinterest towards change in her teaching pedagogies, associated with defensive attitudes and hiding behind systemic issues to avoid critically self-appraising her teaching.

Some of the systemic issues she pointed out, apart from limited time and resources, were particular to the pedagogy we were exploring. She pointed out that doing science investigations frequently made students feel bored, so these lessons should be evenly distributed throughout the term. By expressing issues with this pedagogy, it is evident that Dhasya's understanding of the nature of science or science education did not require active learning or hands-on activities.

Another interesting challenge that Dhasya pointed out contradicted sentiments from the other three teachers: the use of the science laboratory. Although the seating arrangement and the raised teacher platform in the laboratory was a traditional classroom design (see Figure 7.2), the other three teachers preferred conducting science lessons in the laboratory. However, Dhasya pointed out:

> *lab ge structure hunna gothun board ga liyfa explain kohdhey aslu varah undhagoo vey...boadu meyzu kurimatheega hunnathe aslu varah undhagoo*
>
> **Translation**: The structure of the lab makes explaining using [writing on the board] very difficult. This is because the board is in front of the teacher demonstration table. So actually, it makes it very difficult.

(Dhasya Individual Interview, 31 July 2018)

In this section the professional learning journeys of the four teachers in Phase Two of this study are presented as narratives composed through the different data sources. The purpose of presenting these narratives are to show the subjective nature in how teachers make meaning of, engage in, and use TPL opportunities for enhancing their SPS pedagogies. Further, such a teacher-focussed narrative also bring to the focus the micro-processes associated with teacher' professional learning and their pedagogical praxis.

Section 8.2 Collective professional learning and pedagogical development

In the previous section of findings, different ways in teacher's pedagogical praxis for SPS were narrated highlighting the evolution SPS pedagogies and the forms of engagement in various professional learning activities. In this section, I focus on how teachers' individual learning was affected by the collective learning experience and vice versa.

8.2.1 Expanding pedagogic repertoire: *Developing confidence*

From Section 8.1 in this chapter, examination of teachers' narratives demonstrates that **each teachers' pedagogical praxis was different at the beginning and served to determine the course of how their pedagogic repertoire expanded through the professional learning engagement**. In particular, Dhaha expressed

> *mihaaru eba ingay aslu mi skills thah…ingigen kiyvadhey iru eba apply ves kurevey…(after trying) then bodah thorough vefa confident ves vey eba ek-koh aharun teachers mi lessons thah try kureema*
>
> **Translation**: Now I am actually learning these skills in my teaching and am using them because I know them well now. This gives me confidence in teaching the lessons this way.
>
> (Individual Interview, Dhaha, 26 June 2018)

However, as each teacher was introduced to more SPS through group dialogue, co-developed materials, demonstration lessons, and experimenting with the science-investigation-based lessons, each teacher's pedagogical repertoire expanded and yet was very subjective. Teachers' confidence in teaching science also improved, and it could be said that such increase in confidence was not only associated with a development of content knowledge but also through a supportive learning community and knowing that it was not always about teaching the 'right' thing or way (Harlen & Holroyd, 1997).

Such confidence development was evident in two lessons I observed for Dheena and Dhalia (see Figure 8.4 and students' work samples in Appendix A.17).

Comparisons of Dheena and Dhalia's lessons (Weather & Climate -14 May 2008).

Lesson Planning

Dheena expressed she directly used the curriculum outcomes and indicators to inform her lesson plan.

Dhalia expressed she used the teacher's guide to teach (and learn) the lesson content

Lesson starter

As a lesson starter Dheena got students out into the corridor and observe the surroundings for indicators of the day's weather. She made connected the concept to every-day observations (*photo on left below shows students doing this observation*).

However, Dhalia started the question in a traditional approach, using the question 'What is different between weather and climate' and delivered the lesson predominantly using a PowerPoint presentation (*photo on right showing Dhalia delivering her lesson*)

The explanation and students' learning activity - (for more details see Appendix A.17)

Dheena through a pair-work activity got students to classify their observations into 'observations of climate' and 'observations of weather'.

Dhalia got students to individually write answers to set-of comprehension-level questions she wrote on the board.

Overall: Dheena's competency in science content and skills had enabled her to use a more skills-based approach to her lesson, while Dhalia's limited science knowledge had made her use science process skills (such as observation) to delivering information rather than exploring them

Figure 8.4 Comparison of Dheena's and Dhalia's lessons.

Although these two lessons were outside of our co-developed lessons (thus their lessons were different), because this lesson happened after two cycles of professional learning activities, it was interesting to see how both teachers were incorporating their new learning about SPS in their classroom teaching. From this comparison, it is evident that Dheena, with her confidence in her science content knowledge, was able to expand her pedagogical repertoire to incorporate SPS in a more flexible and open-ended exploration style, while Dhalia, with her limited science content knowledge, was more cautious about the pedagogies she used to teach SPS. Dhalia's lesson reflected formalistic pedagogic traditional teaching wherein a teacher explanation is followed by students answering comprehension-type questions (Fittell, 2014; Guthrie, 2020).

Further, for teachers such as Dhaha and Dhalia, although their pedagogies were developing over time, they would often change the sequence of the science investigation so that it became a lesson for *validating* the learning experience rather *exploring*. This shift was due to their limited confidence in their science content knowledge, their understanding of the nature of the school context, or even both, For example, in Dhalia's case for the lesson on investigating water properties, she first explained the concept and said we were going to 'explore' this concept rather than use the conclusions from the investigations to learn more about the concept. Dhalia explained that she changed the inductive[61] sequencing of the investigation to a deductive sequence because 'that way students would not know the concept after seeing it'. It was discussed in Chapter 2 that science investigations are good teaching approaches because of their explorative learning nature that also promotes the nature of science itself. However, teachers' use of the science-investigation as seen in this phase is emblematic of a feature discussed in Chapter 6, wherein **teachers use the investigation-based approach to validate science**

[61] In our planning we had decided to let students explore the investigation and connect their conclusion to surface tension of water rather than explaining the concept before the investigation.

concepts rather than to explore them, which is often associated with a limited content knowledge and confidence.

8.2.2 Introducing more SPS into teachers' pedagogies: *Scaffolding learning*

The **structure of the seven learning cycles aided gradual introduction of the SPS, scaffolding teachers' learning based on evidence from teachers' practice**. Further, such focussed exploration of these pedagogies also enabled me as the professional learning provider to differentiate the learning experiences and scaffold the learning as per teachers' learning needs. The learning goals and class-room observations enabled this focussed scaffolding for each teacher. For example, because Dheena had sound knowledge of science, my support to her was on exploring how she could be more explicit in how she instructed the SPS in her lesson. However, with teachers such as Dhasya and Dhalia, who had limited science content knowledge, I had to explain the skills and the pedagogies during the planning ang reflection sessions. These two teachers also asked me to co-teach with them (discussed in Section 7.4). In particular, from my observation of Dhalia's classroom teaching, I noticed that she requested me to co-teach in order to overcome her feeling of unpreparedness stemming from her perceived lack of knowledge and (moderate) discomfort with the new experimental pedagogies. When trying out new pedagogies and teaching resources, especially when they require certain background content knowledge, such apprehensiveness is common, especially for the teaching science by non-specialised science teachers (Halai, 2012).

Gardiner and Weisling (2016) reported on co-teaching with primary teachers as part of a professional learning mentoring/coaching project and expressed that 'co-teaching can scaffold new teachers' development' (p. 678), while cautioning that too much co-teaching intervention could inhibit teachers' independent teaching. With Dhalia and Dhasya, my co-teaching was impromptu and I would help provide instruction to their students. Afterwards, I would explain to the teachers where and how I had emphasised the science process skill. Such mentoring and coaching through co-teaching developed both Dhasya and Dhalia's understanding of the SPS as well as their pedagogical praxis. Thus, **co-teaching supported the**

development of science content and SPS pedagogies for generalist teachers, especially where teachers had limited content knowledge.

There were other instances too where individualised scaffolding promoted teacher growth and positive changes in practice. For Dheena, when she observed Dhalia's lesson, she used an observation guide which not only helped Dheena to focus her peer-observation but also guided a supporting peer-to-peer dialogue about students' learning and SPS pedagogies (discussed in Section 8.3.4). This tool also improved her own understanding of these skills, evident during Dhalia's lesson when Dheena would inquire about or clarify the meaning of skills, opening space for discussion (see the peer-observation guide, Appendix A.18). **Thus, peer-observations can provide scaffolded learning about SPS pedagogies**.

Further, for Dhalia, the demonstration lesson and the continuity of using the SIBA template in her lesson gradually scaffolded her understanding of SPS. While she was cautious in how she explained these skills to her students, in her focussed lesson planning she was confident in identifying the SPS on the students' worksheet (Figure 8.5). Further, in my observation of the lesson, I noticed more explicit focus on the skills in comparison with her previous lesson. This comparison has been presented earlier in Table 8.2.

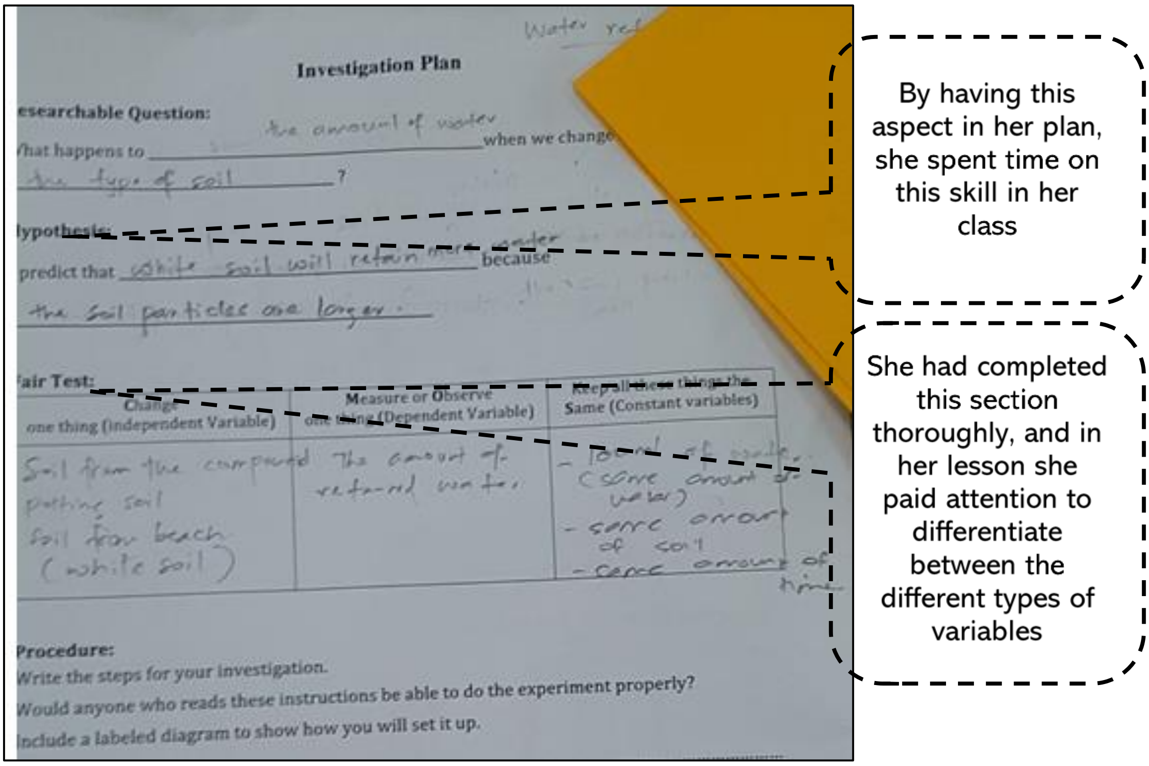

Figure 8.5 Dhalia's lesson plan excerpt.

Note: This lesson is provided in Dhalia's narrative (section 8.1.2)

8.2.3 Professional learning practices: *Flexibility and adaptability*

As the professional learning activities unfolded, I realised that teachers reacted and engaged in the activities differently, requiring **differentiation in how I communicated with the group** and with individual teachers. In particular, due to the participatory approach to this design, I had planned for features such as 'collaboration', 'co-planning', and 'equal-participation' between me and the teachers. However, in light of teachers' passivized working environment and heavy workload, I discovered such expectations were unrealistic (Wenger, McDermott & Snyder, 2002). These authors explained that under such circumstances, the best course of action for collective learning is to understand, appreciate, and **maximise on the different levels of participation that the teachers bring into the community**. Such change in my assumptions enabled more flexibility with the professional learning activities; my communication style also adaptable to teachers' responses. For example, Dheena treated me more as an equal, a stance she assumed at the onset of this professional learning engagement, possibly connected to her leading role in teaching science. Dhalia constantly sought my help and required more assistance and encouragement from me. Dhaha was a bit more independent in her teaching style and offered suggestion only when asked, while Dhasya seemed more passive in her participation in our activities. Using Wenger et al. (2002), classification of different participation levels in communities of practice provides a good explanation in understanding these different levels of participation. I could classify Dheena as a strong core participant while Dhaha and Dhalia were active participants, and Dhasya was predominantly participating at the periphery. These forms of participation were also similar to how their pedagogical praxis evolved over the professional learning engagement. While such classification can be restricting, it allowed me to understand and vary my expectations from the teachers as the professional learning provider. This understanding was heavily aided by my knowledge of the school culture and the broader practices of education in the Maldives (see Chapter 4).

8.2.4 Talking about teaching: *Expanding pedagogic vocabulary and practices*

Overtime, I noticed the changes in teachers' conversations about SPS, in both planning and reflecting on their lessons. As presented in the narratives in Section 8.1, such modes of talk increased after the classroom-research, where teachers had more experience with SIBA pedagogies and associated evidence of student learning. As a group, by the end of the professional learning engagement, **their vocabulary, understanding, and application of SPS in their teaching developed together through their collective reflections on teaching these skills, as evident through their expanded exploratory and reflective dialogue as well as their ability to connect their practices to the curriculum prescriptions**. These elements of talk are briefly presented below.

Role of dialogue.

At the beginning of the learning engagement, teachers were reluctant to offer their input, perhaps due to their limited knowledge about the pedagogies for SPS or simply my role as researcher with them. However, for collaboration and also to make individual learning meaningful, dialogue is important (Armstrong et al., 2005; Barnes, 2008). Further, in science education such dialogue is important for both teacher learning and students' learning (Bianchi & Booth, 2014; Dawes, 2004; Neil Mercer, Dawes, & Staarman, 2009; Rivard & Straw, 2000). Over the course of the professional engagement, **teachers' dialogue improved so that their focus became explorative, reflective of practice ,and connected to students' learning**.

For example, following the professional learning cycle three (lesson topic on investigating weathering), teachers discussed how the investigation procedure was faulty, but learning from the lesson implementation of one teacher supported the implementation of the other, **demonstrating the role of dialogue and reflection in developing teachers' collective pedagogical praxis**.

Me:	Tell me how it went. I understand as Dhalia did it first
Dhalia:	Yes, more time was spent because we were doing more measurements
Me:	Dhaha you tried the other way. What did you think of that?
Dhaha:	Still there were no changes to students' results, they did not make a difference in measurement before and after, plus there was not enough time to do investigation this way.
Me:	So after Dhaha's lesson, Dheena you had your lesson, and you knew about the issues Dhaha had…How did you change the procedure then?
Dhaha:	In my class we still managed to make some observations.
Dheena:	We got some good result, and yes I adjusted the procedure and knew where to focus the time on, based on how Dhalia and Dhaha lesson went, I knew.

(Translated Ground Reflection Discussion, 08 May 2018)

Another interesting role of dialogue was noticed when Dheena was giving Dhalia **feedback on her peer-observed lesson**. Rather than being evaluative and judgmental of Dhalia's lesson, (as discussed in Chapter 4, lesson observations are often associated with teacher evaluation practices), they both engaged in a reflective discussion about how students conducted measurement skills and overall student learning in the lesson.

Dheena: *Mi procedure ga also varah confusion huri dho? Baey kudhin maa barah pipette fithaa ….baey kudhih ai thuru thuru alhaa…then two drops effaharaaa vetti ..mikahla difference ves hurivarah trails ga*

Dhalia: *So ekahala kanthah thah dho mi ingenynee fahun visnaaleema ..aharun aslu demonstrate kurin nama dho hold kuran vee gothaaa, height aaa, pressure level aa fithan vee varaa ehchehi dho.*

Dheena: *Aan adhi eki kudhin comfortable vaa gothah kuran ves bunan vaaney dho, ekamu ehen badhalu nukuraaasheyaslu nubuneyvey. Eygain errors in reading baey groups ga ee ehen-vey eydho. Baey groups huri dho close readings, ekamu aney group ga varah thafaaathu huri*

Translation:

Dheena: There were a lot of confusion in this procedure, right? Some students were pressing the pipette hard, some had shaky hands so ended up putting two drops at a time. So, there were many differences between the trials.

Dhalia: Yea, we are seeing these issues only after the lesson, when we reflect about this. Maybe we should have had demonstrated [to the students] the way to do it, like how to hold, press, the height and pressure, right?

Dheena: Yea, and also told them to do the counting in a position in which they are comfortable, but not to change it. This brought errors in. Some groups had closer readings/measurements while others had very different.

(Dhalia & Dheena Reflective Discussion with Peers, 2 August 2018)

These forms of **reflective dialogue allowed the teachers to explore and engage in SPS pedagogies,** developing their professional repertoire and engagement in about both the content of SPS and the associated pedagogies. Further, because this discussion was focussed on observing students' learning of the skills, the typical evaluative and performative judgements on teachers' practice were diverted in the post-lesson discussion.

Connecting learning to enhanced classroom practice.

For teachers such as Dheena and Dhasya, classroom management was an important feature for how they incorporated these pedagogies into their pedagogic repertoire. As discussed in Chapters Four and Six, **in Maldivian classrooms classroom, management of students' behaviour is a significant feature of teacher's practice and thus it seems that any form of pedagogic innovation teachers attempt must enable teachers to better manage their classrooms**. According to Tabulawa (1998), such managerial pedagogic decision-making and adoption represents a high 'authoritarian classroom pedagogical style' (p. 59).

For example, Dhasya expressed:

> *mihaaru aslu varah dhasvehjjey mi skills kiyavaadheyn mi curriculum ga mi bunaa ehchakee ves mee dho… eh activity ga kudhin ge skills balaafa rangalhu kuran huri kantha faahaga kohfa aneh activity ga bodah ey skills thakah focus kurevey mihen gendhiyaeema. Adhi mihen lesson gendhan fesheema ekkala hyperactive students thah ves varah lesson ga baiveri vaakan fahaga kukrevunu…..kurin ekudhin varah undhaggo vane control kuran..ekamu miharu varah bodah mi difference faahga kurevey*
>
> **Translation**: Now I have learnt how to teach these skills and understood that this is what the curriculum is saying. When we conduct lessons this way it is easy to focus on students' learning and progress of these skills and guide them according to their progress. Also, this way of teaching has helped the hyperactive students to participate and learn. In the past it was very difficult to control them in the lesson, but I have noticed that through this way of teaching their engagement has improved.
>
> (Translated Dheena Individual Interview, 5 August 2018)

8.2.5 Students' response to teachers' developing pedagogical praxis: *Science-investigation-based pedagogies made science fun*

The data from teacher-led classroom-research discussed individually for teachers in Section 8.1 demonstrates how SIBA lessons were making science learning fun and enjoyable for the students. Such **positive response from students made teachers' excited about teaching and learning of SPS**. For example, while analysing Dhalia's students' comments from her classroom-research, she expressed her satisfaction in seeing her students 'excited and surprised…. It made me feel so happy to see students saying this'. Using students' sample of work as her evidence of students learning (discussed in Section 8.2.1), Dhaha expressed how students were positively responding to learning these skills and also using the vocabulary in their classroom, and applying these skills at home.

What we understood from these comments was that students have a positive attitude towards learning science, and their attitude is even more positive when they are doing science investigations (and when applying science skills). Further, when doing the investigations and experiments, students' excitement towards learning and enjoyment towards doing science is enhanced. Furthermore, similar to Dhaha's research lesson, in Dhasya's lesson students also expressed that SIBA oriented lessons allow them to work with their friends, and thus this nature of lesson provides a good socialisation medium for the students, which in turn make learning more enjoyable and valuable to them.

In Dhasya's case, how she used students' evidence was interesting. She initially indicated that students enjoyed the lesson:

> I think they are mostly very interested…they said not interested in science in the beginning, but they did and the way they did it shows that they are motivated…even student Y who said it is boring did the procedure about 5 times and that shows that though he doesn't want to admit, was very interested in the investigation

(Translated Dhasya Individual Interview, 3 July 2018)

But later, **she also expressed that the science-investigation method of teaching was too repetitive, possibly because she felt too pressured and intimidated by using a teaching approach she was uncomfortable with**. During her final interview she expressed:

> When we do investigations-based lessons back to back students (not all) are not interested. That is because we are doing the same thing over and over.

(Translated Dhasya Individual Interview, 31 July 2018)

While Dhalia, Dheena and Dhaha were positive about students' learning and how it impacted their pedagogical praxis positively, Dhasya seemed more ambivalent about it. Her response can again be attributed to teacher level of confidence as well as a potential mistrust towards the ultimate purpose of teacher learning as perceived by teachers such as Dhasya – that it would culminate in teacher evaluation. In performative cultures, it is hard to avoid and overcome the notions and beliefs teachers have around teacher evaluation and critique.

Section 8.3 Challenges for professional practice

In this section, I present findings across these narratives and use data from the overall learning engagement to identify various types of challenges towards professional learning focussed pedagogical inquiry.

8.3.1 Control vs. autonomy

One of the most subtle and yet powerful challenges to the teachers' professional learning comes from the **levels of control** the school, the curriculum, and the structure of existing practices prevalent in the school community. These aspects all seem to influence and limit teachers' pedagogic decision-making and how their pedagogical praxis could evolve. For example, despite advocating the use of active, hands-on activities during the professional engagement, teachers preferred prescriptive-notetaking as evidence of students' learning. As discussed in Chapters 4 and 6, such practices demonstrate 'good teaching' as valued by the school administration and parents. Dheena expressed such **control over her students' learning opportunities:**

> There are lot of notes in the textbook, and though we tell students to read it they don't. So now when we give notes like this for students to write in their notebook. So by the end of the lesson these notes will be there in the book.

(Translated Dheena Individual Interview, 31 July 2018)

Interestingly, **teachers' control of students' learning is reflective of how teachers' own practices are controlled by the school culture**. For example, during one of the first group planning meetings, the grade leading teacher (LT) was present[62] and played a key role in directing the teachers, to the point that she offered teaching resources although it was Dheena's role as the science coordinator to lead the science planning for the grade. I was taken aback by this level of control and associated teacher passivity; in my journal, I wrote the following reflection:

> LT brought some resources (PPTs) that maybe relevant for what the teachers are teaching next week, and she tried to discuss it but there was an air of authority in it that implied that she wants the teachers to try it (*maybe she is doing it because the principal in the SMT had asked them to provide such materials? She implied so....LT has no knowledge of the curriculum requirements so this may not be a good way to impose to the teachers*). Teachers expressed some interest in the resources by saying "oh that is very colourful", "that looks interesting". But not much elaboration or option for discussion on their usage. Maybe they feel like they can't? Maybe they are not interested? This is worrying.

(Research Journal, 06 February 2018)

Apart from these levels of control diminishing teachers' autonomy in their pedagogic decision-making, other school-level factors and practices also impact teachers' pedagogic praxis. Often times, **when teacher's aspirations for innovation and their identities as a progressive teachers clash with the aspirations and identities from the school community, teachers feel frustrated**, causing them to behave as passive practitioners to the point that they lose hope and exctitement about the profession. These are some ways in which schools in the Maldives tend to establish managerial teacher professionalism. Thus, through the learning engagement that this study explored some of the reasons why promotion of democratic teacher professionalsim practices was also difficult to implement.

One particular instance with Dheena is noteworthy to illustrate this point. During one of my interviews with Dheena, which was scheduled following a school-level poem-writing completion, she expressed her frustration with how the school

[62] She was present in most of these meetings.

managed the competition. According to her, the competition was not fair for students who had learning difficulties, a consideration not made by the competition organisers. She discussed the psychology behind treating students unfairly and unjustly and expressed how she pointed out this matter to the competition judges, the school's senior management. She said that while she studies good educational practices and wants to see them implemented, in her school there is no application nor acknowledgement of these matters because 'decisions are made to favour certain teachers and their students'. She concluded, saying she sees no point in learning 'new' or 'better' practices if school's practices do not change.

8.3.2 Systemic challenges

Throughout the course of the six-month learning engagement, numerous systemic challenges constrained the professional learning activities at various levels. While most of them were manageable though beyond our control, there were three major, systemic-level interruptions that impacted the activities. Here, I present excerpts from my research journal to describe these three interruptions, which are provided to highlight the centralised bureaucratic culture and practices prevalent in the schools in Maldives. Further, the **nature of these three interruptions are diverse, demonstrating it is not only the central control of the education system that determines teachers' practices but also the socio-cultural dynamics of the community also determines these practices**.

Interruption one: New practice for parent-teacher conferences.

The Ministry of Education (MoE) decided to implement a student-led approach to parent-teacher conferencing. The memo from the MoE, sent mid-April, instructed all schools that this parent-teacher meeting was to take place in the last week of April. We were used to a traditional form of parent-teacher meetings wherein the teacher showed parents what the students had been doing and where they needed improvement. In this form, student input into the conversation is minimal, so opening the format to include students was a new approach that required training for both teachers and students. Teachers were completely overworked in trying to prepare for this new approach to parent teacher meetings during the last two weeks of April. As a result, all teaching was parked until this important policy imperative was accomplished.

Once these parent meetings were over, I managed to meet the teachers on 3rd May to discuss their first lesson—almost two months after I started my fieldwork activities. Due to this interruption, the third learning cycle went on for two weeks, necessitating various changes to our activities.

Interruption two: Ramadan timing and school closure due to flu outbreak.

We all planned for the last two weeks of the Ramadan to trial a more open-ended investigation approach, which was possible then because it was end of the term and there was time without focusing on content learning. This timing meant students could do a more organic and flexible investigation and present their findings to the school or similar.

I had planned for this (group meeting), but school closed due to flu outbreak and the teachers decided to start the next term afresh from the next topic. This affected everyone's second set of goals and pushed two of my input sessions with the teachers to the last few weeks of my time with them.

Part of this interruption was foreseen (Ramadan schedules), but the flu outbreak and associated school closing was unprecedented. As a result, after learning cycle three, we had to pause our learning engagement for a month. The implications of this on the learning made it difficult to pick up our engagement once schools opened.

Interruption three – School-based thematization of the curriculum.

As part of familiarising the teachers to the curriculum and making its implementation holistic, MoE had all the schools in Maldives undertake thematising exercises for the curriculum. This activity required that all the curricular subject content (using the curriculum outcomes prescribed in the curricular documents) for each grade would be reorganised under 10 themes. The themes were decided by the MoE itself. Each week, teachers were to report on various activities designed to help in this overall process of thematising. For example, in the first two weeks, teachers had to classify the curriculum outcomes under each of these themes. This exercise required teachers to develop units of teaching for these themes, based on the outcomes identified. The Ministry set out deadlines and the school's leadership were to be accountable for this work, meaning that they put a lot of pressure on the teachers to complete these tasks. However, the despite the fact this thematizing was done so urgently, the school was required to use them the following year.

This interruption although did not impact teachers' classroom time as interruption one did, but due to this interruption, scheduling meetings was difficult. Teachers' priority was to attend to this thematising activity and our professional learning activities kept being pushed to the backburner.

In this section, some of the challenges for a long-term TPL engagement has been explored. Systemic issues associated with a top-down education system have been identified, together with issues associated with generalist teachers requiring to teach specialised subjects such as science, have been identified. These challenges pose significant limitations on teachers' ontological and epistemological practices and aspirations for TPL and pedagogical praxis. In the next chapter I discuss, on these findings.

Conclusion

In this chapter, the four teachers' individual and collective professional learning experiences have been narrated. The purpose of these individual narratives was to demonstrate the subjective nature of learning and also highlight the micro-processes associated with TPL, together with the nature in which teachers engage, make meaning of, and develop their pedagogical praxis. Further, in this chapter, various collective practices were also identified, highlighting how pedagogical praxis regarding SPS can evolve with sustained and collective professional learning opportunities. Finally, this chapter has also illuminated how the socio-cultural practices within a school and community at large can affect teachers' professional learning practices. Such challenges are important to argue as contextual contingencies need to be addressed in designing and implementing teaching professional learning. Such contingencies for developing pedagogical praxis and professional learning are discussed in detail in the next chapter.

Chapter 9. Discussion

> The teaching profession is dramatically strengthened when teachers understand who they are, know how their experiences have shaped their ideologies, and find and acknowledge their place of contribution in the broader context of the educational setting.
>
> (Sameshima, 2008, p. 34)

Introduction

The aim of this research was to explore upper primary (Grades 5 to 6) teachers' professional learning of science process skills (SPS) pedagogies. In this chapter, to elucidate the answers to the questions guiding this study, the findings which were presented in Chapters 6 to 8 are discussed; the summarised answers are offered in the final chapter. Section 9.1 begins with discussion of findings relevant to SPS pedagogies to help answer Research Questions 1 and 2, namely: .

RQ 1. How do primary teachers in the Maldives conceptualise and support their students to develop science process skills and its pedagogies?

RQ 2. What pedagogies for science process skills are possible and meaningful for primary teachers in the Maldives?

Section 9.2 discusses features of TPL to help answer Research Question 3, namely:

RQ 3. How can a professional learning inquiry engage primary teachers in exploring and enhancing their pedagogies for science process skills?

This chapter concludes by bringing together the discussions in these parts to reiterate the significant connections between teacher professional learning (TPL) and teachers' pedagogical praxis highlighting their contextual contingencies.

Section 9.1 The terrain of science process skills pedagogies

In this study, pedagogy of teaching SPS is broadly conceptualised as a praxis and process that connects teachers' practice with their pedagogical development. It has been shown in this study that the processes associated with such a pedagogical praxis are far more complex than simply following a pre-defined, prescribed curriculum. As such, a **key argument made in this thesis is that SPS pedagogies based on constructivist learning theories *do* provide a basis for contextually contingent, socio-culturally-sensitive, and meaningful pedagogies for generalist teachers.** I discuss below the reasons behind this argument.

9.1.1 The nature of SPS pedagogies

As argued in Chapter 2, most science education pedagogies are grounded in constructivist learning theories. Often these pedagogical approaches are presented as progressive education practices such as LCE. This research has highlighted that application of constructivist and progressive pedagogies in practice is deeply complex, necessitating an expanded understanding on the nature of these pedagogies beyond the simple labels of progressive education or constructivist learning.

Phase One of this research showed that teachers' limited conceptualisations of SPS impact their pedagogical application of these skills. Similar to Loughran's (2013) observation, this study also observed that teachers' knowledge and practice of SPS pedagogies are limited. Teachers' practice and experience of SPS were limited to basic skills (such as observing, measuring, and classifying), and curriculum opportunities for teaching and integrating SPS tended to be overlooked in practice. Such limited practices are common when teachers are unfamiliar with the curriculum (Shiyama, 2016) and its orientation (Mohamed & Karuku, 2017); misapplication especially occurs when the curriculum is overcrowded and when teachers are driven by performance standards and external measures of productivity (Day & Sachs, 2004; Halai, 2012). Those standards and productivity measures tend to enforce 'cover the curriculum' discourses and practices amongst the teachers. Despite these prevailing pedagogical practices and norms, the professional learning activities of Phase Two in this research have illuminated two fundamental features of the nature of SPS pedagogies that require deliberation when in circumstances where teachers have only a limited palette of pedagogies (Barrett, 2007; Schweisfurth, 2011). These features are discussed below.

Importantly, the different ways the four participants in Phase Two engaged with SPS pedagogies signifies that progressive constructivist pedagogies of inquiry-based, investigation-based-science pedagogies are not a one-size-fits-all approach. This concept can be explained in two ways. To begin, numerous contextualised factors and systemic issues (such as nature of the students, comfort level of the teacher, school resources and availability of instructional time[63]) both directly and indirectly determine a teacher's understanding and application (Goodnough, 2008) of SPS pedagogies. Science education researchers such as Park et al. (2011), Loughran et al. (2001), and in particular comparative science education researchers such as Asabere-Ameyaw et al. (2012), Le Grange (2007), and Tikly (2019) have all highlighted the context-specific, subjective, and idiosyncratic nature of constructivist science pedagogies. In this regard, Taber (2006) argued that the nature of constructivist pedagogies is not about learning a single notion of science, or a single approach to teaching science (and its skills) but instead require teachers to utilise constructivist approaches such as scaffolding and other socially-acceptable and culturally-available tools and resources to enable students to re-create their concepts of science. Thus, **contextual contingencies** and **culturally-relevant constructivism** (Cobern, 1996) are both significant aspects of pedagogies for SPS.

Additionally, since pedagogies for SPS have come from Western, Anglophone cultures where education systems have the strength and resources to practice progressive constructivist pedagogies, the issue of cultural relevance and

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[63] Haberman (2010) and Barton (2007) content such issues of 'pedagogy of poverty' often runs counter to progressive pedagogies. This is because, pedagogy of poverty may have contributed to success in science learning as rule following and cognitive passivity, where conceptual learning maybe overlooked.

congruence (Guthrie, 2011) arises when trying to apply these pedagogies in non-Western contexts. Additionally, while these SPS are important for teaching science, Tikly (2019) raised the question of how an 'over-reliance on logic-deductive forms of inference' (p. 193), as a Eurocentric epistemology, can be compatible with the local epistemologies practiced and valued by teachers in the Global South. The Western contexts from where SPS and associated pedagogies have emerged have numerous organisations, affiliations, and multiple resources which develop scientific ideas and from which teachers can seek epistemological support. In the Maldives, our science and technology industry is often associated with *applying* scientific knowledge rather than *developing* it. The applied science that is practiced in fishing, agriculture, and tourism tends to be developed elsewhere. With such a limited practice within the science and technology industry and limited community-based opportunities for engagement in science[64], teachers' exposure to various forms of science learning tends to be limited to pre-service training or the sporadic transmissive modes of in-service PD engagements. Thus, as this research indicates, the forms of school science that exist in the Maldives tend to be removed from the 'real-life' context of Maldivian students because teachers are made to promote Eurocentric views on science. Under these circumstances, adopting pedagogies from teachers' socio-cultural norms and traditions to teach Eurocentric science inadvertently creates conflicts (Schweisfurth, 2013a) in teachers' pedagogical praxis.

However, such conflicts open up opportunities to create unique 'hybrid' pedagogies where there are elements of familiarity mixed with pedagogical innovations (Barrett, 2007; Di Biase, 2019; Guthrie, 2020; Schweisfurth, 2015; Tikly, 2019). For example, while the SIBA template of students' activity allowed open exploration and practice of SPS, due to the school's performative norms, teachers had to ensure that all students 'completed' the worksheet and had common notes, so teacher-prescribed notetaking was incorporated into this pedagogy. However, teacher

[64] Such as science centres or museums.

educators and curriculum developers in the Maldives seem to view such hybridisation as teacher incompetence in implementing progressive pedagogies. What we need to acknowledge, then, is the nature of these pedagogies: when innovative progressive constructivist pedagogies travel (Schweisfurth, 2013a; Sriprakash, 2012), they inevitably hybridise with performative traditional pedagogies which exist in the locality. These pedagogies evolve to become contingent on the social-cultural norms and traditions of the schools. According to Mhakure and Otulaja (2017), such hybridisation of pedagogies demonstrate that traditional conservative pedagogies can complement constructivist pedagogies. Thus, the nature of these pedagogies for SPS are more suited as **contingent constructivism**, that is, they are more attuned to the 'country's cultural, economic and political conditions' (Vavrus, 2009, p. 304).

Secondly, teachers' understanding of the SPS and their belief of its place in science education also plays a critical role in the nature of the pedagogies they employ. Dheena's science background knowledge was an asset for her pedagogical praxis as she could use her knowledge, as evident in her flexible adaptation of the sequence of SPS in most of her science lessons. However, Dhasya and Dhalia, with their limited science background knowledge, did not have the confidence nor the competence to explore the potential of these pedagogies in their classrooms beyond what was on our co-planned lessons. Thus, investigation-based pedagogies that explicitly focus on SPS require a certain level of teachers' science content knowledge (Dillon & Manning, 2010; Fitzgerald, 2012; Robinson, 2017) that connect teachers' pedagogies to their views about science education and nature of science (Anderson, 2015). Most teachers in Phase Two of the research, even by the end of our learning engagement, seemed to have not fully realised that implementing SPS pedagogies in the science classroom is not just about a change of pedagogy as classroom practice, but implementation requires a change with deeper ontological and epistemological shifts to teachers' views of science and science learning (Halai, 2012; Windschitl, 2002). In Anderson's (2015) study with three generalist primary teachers on their practices and beliefs of science education, a range of practices similar to this study were identified. He found that what guided teachers' pedagogies were learning about 'science as a product', rather than the 'nature of science' itself. Congruently, most teachers from both phases of this study were unable to connect their pedagogies to nature of science to the processes of science learning.

As discussed in Chapter 2, ontologically science has both realist and relativist elements, necessitating epistemologies that rely on the senses but also socially (re)constructing the body of science knowledge that is meaningful for the inquirer (Asabere-Ameyaw et al., 2012; Le Grange, 2007; Tikly, 2019). Such an explorative epistemology cannot be reflected in classroom teaching where teachers' ontological and epistemological views on the nature of science and SPS are limited. These limitations create a mismatch between pedagogical relevance of prescribed curriculum and the pedagogy that is experienced, with worrying consequences for the generalist primary teachers' pedagogical praxis of teaching science outside their specialism. Before discussing some of these effects (Section 9.1.3), I first apply Nind et al.'s (2016) conceptual framework for pedagogies to empirically explore and understand the different dimensions of SPS pedagogies and how each of these dimensions impact teachers' pedagogical praxis.

9.1.2 Pedagogies as specified to pedagogies as experienced: *Hierarchies and the locus of legitimacy*

This research has illuminated the complexities, messiness, and challenges associated with conceptualising the three dimensions of pedagogy that Nind et al. (2016) have proposed (see Section 2.2.3). These dimensions were *pedagogy as* ***specified***, *pedagogy as* ***enacted***, and *pedagogy as* ***experienced*****.** This research indicates that various discourses, challenges, and practices are created at each dimension, and in the process of moving from one dimension of pedagogy to the other. In particular, there exists a hierarchy of pedagogical knowledge and practices established across these three dimensions. These hierarchies also seem to be legitimised by the top-down centralised nature of the education system that places the locus of knowledge within this hierarchy where the power and authority of the actors involved in determines the nature of pedagogy at each dimension. As such, the pedagogies specified being at the top of this hierarchy assumes the most power, and thus legitimacy in directing the pedagogies that are relevant for the students. The findings in relation to each of these three dimensions are discussed below.

Pedagogies as specified: curriculum, policies and 'best practices'.

Pedagogies for SPS specified in the curriculum represent rational, technical, and reductionist approaches to pedagogy (Nind et al., 2016). The science curriculum in the Maldives stipulates that:

> Effective science learning and teaching take place in a variety of situations. Instructional settings and strategies should create an environment which reflects a constructive, active view of the learning process. Learning occurs not by passive absorption, but rather as students actively construct their own meaning and assimilate new information to develop new understandings in terms of knowledge, skills and values and attitudes….
>
> Learning experiences in science education should vary and include opportunities for group and individual work, discussion among students, as well as between teacher and students, and hands-on/minds-on activities that allow students to construct and evaluate explanations for the phenomena under investigation. (NIE, 2015a, p. 13)

These statements in the science curriculum work together with statements from the Pedagogy and Assessment Guide (PAG) for the curriculum, which describes itself as a guide 'that pull together some of the current best teaching practices that are supported by research' (NIE, 2014, p. 6). Together, they are advocating progressive versions of constructivist pedagogies. The curriculum promotes LCE-based inquiry-learning approaches as 'the' way to teach science. Further, the science curriculum prescribes almost all of the SPS identified in Chapter 2 to be taught within primary science in the Maldives. The curriculum-prescribed skills are: 'Observing, Classifying, Recognising Patterns, Estimating and Measuring, Questioning, Making and testing, Predicting, Investigating and experimenting, Recording and communicating, [and] Designing and Making' (NIE, 2011, p. 19).

As identified in Chapter 2, this list is a prescribed and comprehensive compendium of science process skills; prescribing the teaching of all these skills at primary schooling is an overambitious expectation. Such overloaded curriculum directives, especially from an OBE orientation, do not provide much flexibility for contextualising the prescribed pedagogies nor the SPS, because these curriculum directives imply pedagogy is context-neutral. Further, these curriculum prescriptions do not consider the applicability of these skills across the primary grades either. For these reasons, these curriculum prescriptions can be said to demonstrate heavy, uncritical borrowing of Western-Anglophone pedagogies (Barrett, 2007; Crossley, Bray, & Packer, 2011). As discussed in Chapter 4, such an uncritical borrowing is common in the Maldivian education system, where Western-Anglophone ‘expertise’ and practices are revered and promoted as ‘best practice’. Mohamed and Karuku (2017) made similar observations in the Tanzanian context. Such uncritical practices enter the curriculum because curriculum developers are often civil servants removed from the realities of primary classrooms (Reiss, 2015), and they are advised by the ‘international expert’ consultants brought in by powerful donor agencies (Tabulawa, 2003).

From Phase One of this research, it was ascertained that teachers used the curriculum without understanding its structure, language, or orientation; they used it simply with the technique of ‘covering’ material as if in a race. Further, as per curriculum prescriptions, teachers employed various constructivist pedagogies to inform their classroom activities, but oftentimes these pedagogies were applied as a confirmation tool to verify science content that had already been taught. Similarly, in Phase Two, Dhasya expressed that her responsibility is ‘following the curriculum content’ rather than ‘wasting time’ on hands-on investigation. These practices and discourses highlight teachers’ resignation to a power imbalance where an (external) curriculum authority dictates teachers’ classroom pedagogies; thus, teachers’ responsibility is to performatively ‘show’ the pedagogy or ‘cover the curriculum’. Such practices signify how these teachers’ revelatory epistemologies of authoritarian practices (Guthrie, 2003, 2011, 2018, 2020) not only facilitate the uncritical and selective uptake of curriculum-prescribed pedagogies, but also how these uncritically gets (re)produced in contexts where teachers’ autonomy and pedagogical freedom are limited.

Another curriculum-specified finding relevant to SPS pedagogies is the deficit-views of teachers prevalent within the community of TEs and CDs, despite evidence of contextual and systemic hinderances to such implementation (Di Biase, 2015; The Maldives National University, 2016). The CDs vehemently defended the validity, quality, and viability of the new OBE curriculum[65]; though they did not acknowledgement the systemic challenges of curriculum implementation (such as lack of resources and poor pre-service and in-service training), they also did not demonstrate an understanding about the contextual relevance of the curriculum itself. Their beliefs around the universalism of progressive education as 'best practice' (Klees et al., 2020) were manifested in their discourse and are enforced through the curriculum documents.

Similarly, TEs' views of teachers' SPS pedagogies were filled with statements such as 'just doing it for the sake of doing it' and, 'teaching is superficial'. CDs also indicated that teachers 'lacked content and pedagogical knowledge', demonstrated 'superficial teaching and no deeper thinking' and thought that '...these [science process] skills are part of the pedagogy and they don't see it that way'. This demonstrates a reductionist, pejorative discourse, fostering deficit views of teachers that tend to devalue teachers' pedagogical expertise. In so doing, the curriculum and *pedagogies as* ***specified*** reaffirms their legitimacy and control of pedagogies. Thus, a hierarchy of pedagogical knowledge is established and propagated, where authorities such as CDs, TEs, and external donor-funded experts are seen to be on top of the hierarchy. These hierarchies and discourses represent an epistemological view that assumes knowledge of pedagogies to be the privileged domain of those elite stakeholders (Schweisfurth, 2013b; Tabulawa, 2013). In fact, these practices and views contradicts collegial, autonomous teacher professionalism practices.

[65] The argument was that the curriculum in Maldives is following 'best-practice' example from Australia, based on their 'external' expertise input into the development of the curriculum.

Pedagogies as enacted: teachers' competencies, socio-cultural backgrounds, and resources.

In a typical Maldivian classroom, the expectation on teachers is that the prescribed curriculum will be implemented without much adaptation or resistance. Such expectations seek teachers' compliance with prescribed pedagogies, and yet teachers' interpretations of these pedagogies tend to be defined by their limited understanding of the curriculum, together with the systemic challenges they face. Thus, the pedagogies teachers enact are determined by the tools, experiences, and opportunities teachers have (Nind et al., 2016).

As has been seen from this study, when teachers are offered limited tools in translating the prescribed pedagogies into their enacted pedagogies, teachers practice a superficial interpretation of the curriculum, one that is emblematic of a 'tendency to treat indicators and measures as synonymous, and to the distortion which follows an excessive preoccupation with measures' (Alexander, 2008, p. vii). Thus, while curriculum indicators are supposed to guide teachers' pedagogies for SPS, in practice these measures tend to be reduced into a tick-box routine that is further escalated by schools' practices of performativity and the MoE's push for curriculum fidelity (Marsh & Willis, 1999).

Another layer is put on *pedagogies as **enacted*** is the availability and utilisation of resources such as textbooks and laboratory materials which parade as 'the' legitimate sources of information and enablers of pedagogical practices. In the Maldives, we have a saying: '*fotheh othakas edhureh nuvaane*' [transliteration: A book will not do the teaching]. Ironically, despite this cultural maxim, it is expected that, with the provision of resources and textbooks, quality teaching and learning will follow. Reliance on 'teacher-proof' textbooks as the legitimate source of content and pedagogy is a feature prevalent in LMICs and SIDS' education systems (Phillips & Schweisfurth, 2014). Teachers' pedagogical choices have an overreliance on these textbooks to inform (and limit) the content and pedagogies of their science lessons, to the point that teachers often hold textbooks in high authority, a practice often found where revelatory epistemologies hold sway (Guthrie, 2018). Such practices demonstrate the locus of pedagogical knowledge that comes from an understanding of the curriculum and the knowledge of how textbooks are used to inform, rather than prescribe, classroom practice. However, as demonstrated by this study, teachers are not exposed to such pedagogical knowledge nor such practices. Implications of this limitation upon generalist teachers' practices are discussed later in Section 9.1.3.

Guthrie's (2015b) observations in the Papua New Guinean[66] context, where 'curriculum-driven progressive[67] reforms of OBE have failed to replace formalistic classroom teaching' (p. 33) resonates with this study. The formalistic approaches Guthrie (2015) highlighted are those teaching pedagogies that stem from deep-rooted cultural traditions present in the informal-learning systems. As indicated in Chapter 4, in the Maldives, practices such as learning to recite the *Qur'an* in early years and early religious learning in informal settings significantly shape teachers' pedagogical practices (Adam, 2015a) of 'teaching as they were taught'. Thus, the rigid nature in which most of the teachers engaged with the science-investigation-based approach, by dictating answers to investigation procedures and conclusions, the heavy adherence to classroom control, and discipline while conducting investigations, can be explained by **teachers' overwhelming subscription to traditional practices**. Similar observations have also been made in other contexts where traditional formalistic pedagogies prevail. For example, Vavrus (2009) and Barrett (2007) highlight the realities for educators in Tanzania who engage with and adapt LCE pedagogies that are a far cry from the teachers' established cultural/traditional pedagogies. Sriprakash (2010) observed from a rural Indian context that 'learning was largely understood as knowledge assimilation (the acquisition of the syllabus) rather than knowledge construction' (p. 303). Similarly, from the South Asia context, in Pakistan, Halai (2012) concluded that science teachers struggle to find a balance

[66] Is relevant for comparison here because it is a SIDS similar to the Maldives

[67] Such as learner centred education (LCE).

between innovative progressive pedagogies for science and their current methods, which created barriers to accept progressive pedagogies. In another South Asian country, Bhutan, in an analysis of the science curriculum, Childs et al. (2012) reported conflicts between the modern science education system and its progressive teaching approaches with that of the monastic system of education and its spiritual teaching approaches about myths and traditions. In the same vein, Tabulawa (2013) wrote, asserting Altinyelken (2010), that we should move beyond a rhetoric that 'lament[s] the failure of efforts to implement learner-centred pedagogy in sub-Saharan Africa' (Tabulawa, 2010 p. xvii), but instead we should ask the question regarding the *appropriateness* of these forms of pedagogies. Di Biase (2019) argued that progressive education such as LCE in its 'pure' form may not be accessible nor appropriate to context such as the Maldives because teachers' conceptual knowledge of science, the availability of resources, and the overall socio-cultural context of Maldivian classrooms makes certain forms of pedagogies possible to enact. Such contingencies are discussed further in Section 9.1.3.

Pedagogies as experienced: interpreting, transforming and reflecting.

As the scope of this research is teachers, the focus here is on pedagogies as experienced by teachers. Nind et al. (2016) explained that 'pedagogy as eperienced' is complex because of the subjective nature of all the actors involved in the pedagogical experience. This subjective nature of pedagogies together with its contextual contingencies require a deeper and longer-term engagement with teachers to unravel and understand how SPS pedagogies are experienced by teachers. Phase Two of this study provided such an engagement, with a long-term project showing these idiosyncrasies in the SPS pedagogies that teachers undertake. As argued in the previous section, one way in which the complexities in pedagogical experience arise is from the uncontextualized nature of the curriculum prescriptions that tend to get magnified when teachers are required to implement them dogmatically (Guthrie, 2003).

It is acknowledged that teachers' cultural and traditional practices, together with the systemic issues in the education system shape teachers' experienced pedagogies (Al-Balushi & Ambusaidi, 2015; Childs et al., 2012; Halai, 2012; Mansour, 2013b, 2013a, 2015; Schweisfurth, 2011; Sriprakash, 2012), but as indicated by this research, there are numerous ways in which teachers' pedagogies are shaped. A finding from Phase One that was later affirmed in Phase Two is how parental expectations and pressures have shaped teachers to continue some of their pedagogical practices in spite of curriculum prescriptions. For example, the OBE curriculum in the Maldives advocates multiple modes of formative and summative assessments, with a stronger emphasis on formative assessments in primary grades (NIE, 2015a). However, parental expectations of pencil-paper summative assessments, together with schools' performative cultures maintains an exam-driven, content-oriented teaching culture, affirming the legitimacy and value of performative pedagogies.

Such practices also remain in the system because when already-overworked teachers are bombarded with top-down policy imperatives which take no consideration of the classroom realities of limited time, resources, and conceptual knowledge, teachers have no opportunities to engage in these policies meaningfully but must (uncritically) follow them. The existence of rule-following school cultures (discussed in Chapter 4) legitimises these forms of policy implementation. Further, the gendered nature of the teaching profession, especially the primary teacher population, seems to have an impact on teachers' pedagogical choices. According to OECD (2009), in most countries worldwide, the primary teacher population is predominantly female and those women maybe more open to practice progressive pedagogies. However, in Maldivian culture, the woman's role as teachers is to be submissive and passive, as demonstrated by teachers' preference to follow the status quo and adhere to authority. This gendered nature may bring positive caring practices, especially in the primary grades (Pezaro, 2017), yet findings from Phase Two of this study also indicate that for women teachers in the Maldives, though they spend a considerable amount of their time on school-related tasks, a very small percentage of time can be devoted for meaningful engagement in their pedagogical praxis.

Finally, both phases of this study indicated that generalist teachers' limited language competencies in interpreting the curriculum documents are associated with the complex terminologies in the curriculum and the fact that the curriculum is in teachers' second language. It is noteworthy here to point out that the way in which these features shape teachers' pedagogies are sometimes so subtle that teachers themselves are unaware of how much the system (negatively) influences their pedagogies. Further, similar to most developing countries, in the Maldives the status of teaching as a profession is slowly deteriorating (L. Hargreaves, 2009), making teachers' incentives for pedagogical revival and engagement difficult to advocate for. This study has illuminated how these systemic, socio-cultural, and contextual features can heavily impact teachers' *pedagogies as* ***experienced***.

However, this study has also demonstrated that despite these limitations, if teachers can focus on subject matter pedagogies, and they are collegially supported to overcome fears of criticism for curriculum infidelity, teachers can be flexible and more aware of how they adopt/adapt their pedagogical praxis. For such an exploration of pedagogies, supportive communities of practice and evidence from classroom teaching are critical (Bishop & Denley, 2007; DuFour, 2004; Loucks-Horsley et al., 2010; Osborne et al., 2019). However, as demonstrated by this study, in the Maldivian primary school setting, one way to establish this sort of professional learning community initiative is one where TEs and CDs participate with teachers as equals (Mitchell, 2013). Thus, through such practices, the legitimacy of pedagogies as experienced will then come from teachers' collective collaborative efforts and the teacher-community's value of their pedagogical practices, so that the locus of pedagogical knowledge is within the community of teachers.

Summary of sub-section.

In this sub-section, I have discussed how this research has demonstrated **the idiosyncratic, unique micro-processes of how SPS pedagogies move from *pedagogy as specified* through *pedagogy as enacted* to *pedagogy as experienced*.** The critical argument here is to illuminate the hierarchy of pedagogical knowledge and practices that are established across these three dimensions. As argued here, these hierarchies are legitimised and propagated because in top-down, centralised education systems, those in power defines the epistemological boundaries and possibilities that teachers (and students) experience. Further, the cultural norms and practices of formalistic pedagogies promote these hierarchies and legitimacies. The arguments here across the three dimensions are presented in Table 9.1.

Table 9.1 Legitimacies and pedagogical knowledge hierarchies

	Pedagogy as Specified	Pedagogy as Enacted	Pedagogy as Experienced
Legitimacy of pedagogical knowledge and practice	From existing practices of reverence to **cultural revelatory knowledge**, and authoritarian practices	The **competence** of teachers, '**training**', experiences and specialised knowledge gives authority to interpret the curriculum	Teachers' experiences, **content knowledge**, shaped by the **socio-cultural facets of the system,** school and ministry policies and parental expectations
Locus of pedagogical knowledge and practice	***External to the teachers*** The curriculum documents, policies and 'best practice'.	***External to the teachers*** The PD providers, the 'experts', resources and textbooks ***Internal to the teachers*** Teachers' familiarity to the curriculum	***Internal to the teachers*** In the temporality of classroom teaching and interactions, informed by experiences and shaped by cultural norms and practices

Further, in this sub-section, I have discussed the mechanisms through which a rarefied conceptualisation of SPS pedagogies within prescribed curriculum leads to an incomplete, superficial experience of pedagogy for both teachers and students. Consequently, learners are only engaged in a limited conceptualisation of SPS. The rarefication of the knowledge of experts and 'best practice' discourses casts teachers as automated implementers and transmitters of 'best-practice'. Thus, enactment becomes performance rather than interpretation or engagement of Deweyan experimentation (Johnston, 2009). Consequently, teachers' pedagogical praxis is built on a superficial understanding and selective teaching of SPS because teachers do not have the tools nor knowledge[68] to engage in, nor critique, these 'best-practices' to inform and innovate teachers' pedagogical praxis as inquiring professionals.

In summary, while *pedagogy as **specified*** seems to alienate teachers from their classroom realties, *pedagogies as **enacted*** tends to create a deficit discourse on teachers. Pedagogies as experienced while potentially provides some autonomy for teachers in pedagogical practices, the systemic challenges inhibit such exploration and any legitimacies associated with teachers' voice in pedagogical decision-making. These arguments are presented in Figure 9.1 as my contribution to expand on the dimensions of pedagogies proposed by Nind et al. (2016). These additions explain the processual, relational, and contextual nature of pedagogies (Alexander, 2004; Barrett, 2007; Loughran, 2013; Schweisfurth, 2011) and illuminate some critical elements involved in moving from one dimension of pedagogy to another in contexts where systemic and contextual constraints have established teacher passivity.

[68] Such as pedagogical knowledge, content knowledge, and comparative education knowledge.

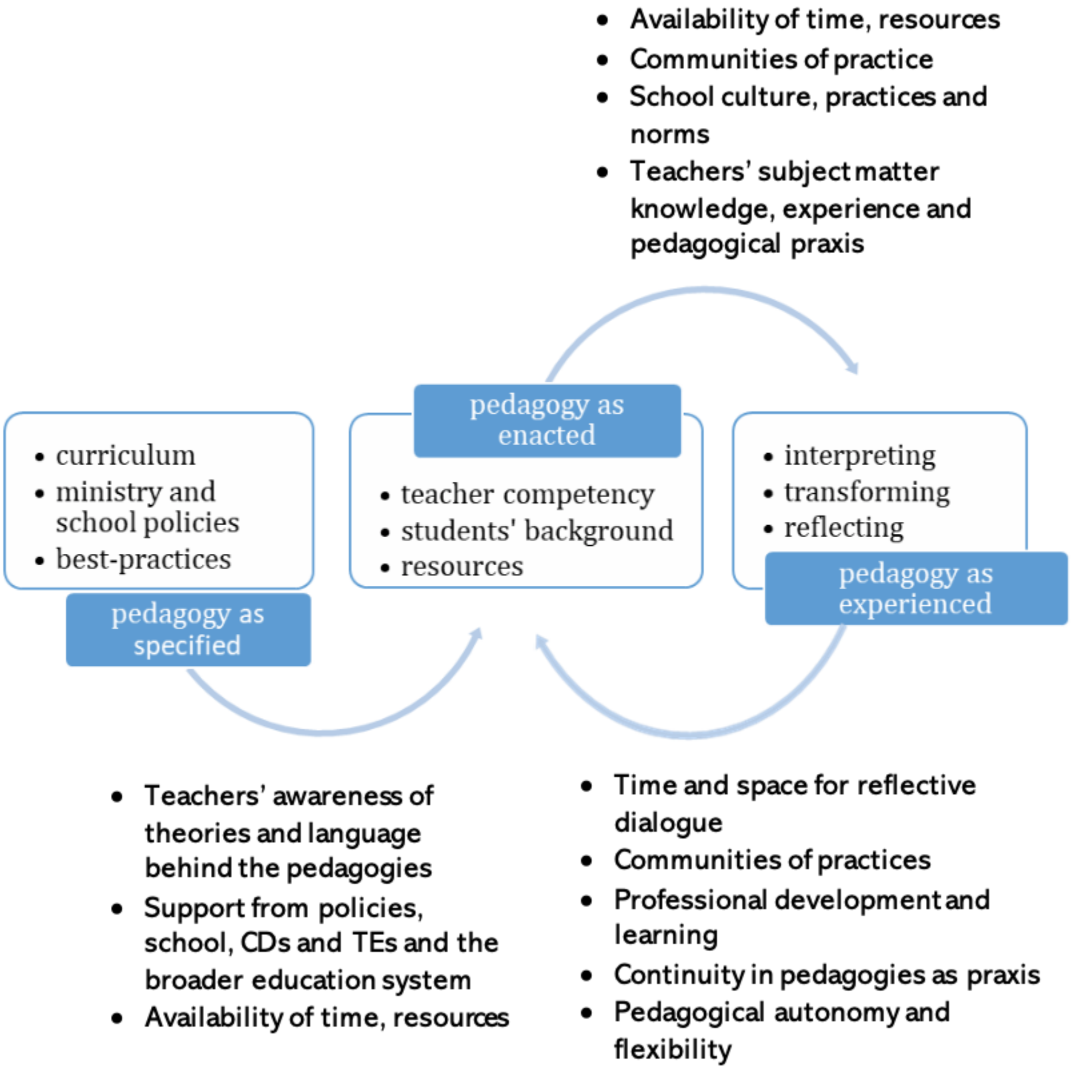

Figure 9.1 Expanded version of Nind et al. (2016)

Model of dimensions of pedagogies and associated processes.

Note: The expansions demonstrate the processual and relational nature of pedagogies while also highlighting how hierarchies of knowledge is set through these dimensions

9.1.3 Contextual contingencies in pedagogies for SPS

As discussed previously in Section 9.2.1, the nature of SPS pedagogies that is practiced raises the issue of relevancy of inquiry-oriented science-investigation which has roots in progressive pedagogies such as LCE. While the curriculum documents heavily emphasise constructivist progressive pedagogies for SPS (NIE, 2014, 2015a), this research raises the question of relevance and feasibility of such pedagogies for the teachers. The four teachers from Phase Two engaged and interacted with progressive constructivist pedagogies for SPS based on their level of familiarity with the science content and skills. A possible reason for such a difference could be because progressive constructivist pedagogies are radically different ‘from the traditional educational model in which teachers themselves were schooled, making it especially difficult for them to visualise constructivist pedagogy’ (Windschitl, 2002, p. 138).

These findings concur with the work of Smith and Neale (1989), Park and Chen (2012), Osborne et al. (2019), Hackling, Peers, and Prain (2007), and Halai (2012) in indicating the importance and relevance of subject-matter knowledge and pedagogical knowledge[69] for teachers’ pedagogical praxis. However, the contextually rich findings of the microprocesses of classroom pedagogies from this research expands upon their conclusions. Dhasya found no relevance in teaching certain SPS (for example, identifying variables) and heavily stressed basic skills such as observing, classifying, and measuring. As identified in Chapter 8, she taught those skills in a predominantly prescriptive formalistic manner, emphasising the ‘content’ of science rather than the skill of science. She further defended such a content-based approach explaining that SPS could be managed inside the typical classroom, moving beyond the popular rhetoric and practices wherein ‘science investigation is to be done in the lab’. However, Dheena demonstrated her expanded understanding of the relevancy of these pedagogies and the SPS itself. She incorporated the SPS more flexibly into her science pedagogies; her application of SPS

[69] According to Shulman (1986) and Kind (2009) pedagogical knowledge focus on teachers’ beliefs and practices that inform their classroom teaching and learning decisions, instructions such the use of models, analogies, performances or visualisations that enables teachers to explain the topic and the in such a way that learner can distinguish between, and understand school science and science knowledge.

was evident in lessons beyond the research data collection lessons. However, the other teachers limited their SPS pedagogies to our co-planned lessons only.

Dheena also demonstrated her pedagogical flexibility in adjusting the sequence of these SPS and dynamically applying these skills in her pedagogies, similar to how Harlen and Elstgeest (1992) conceptualised the pedagogies. Conversely, Dhaha and Dhalia found inquiry-oriented investigation-based pedagogies to teaching SPS somewhat relevant to their science teaching. They adopted the investigation-based lesson that we planned but followed the lesson sequence rigidly. However, such lessons were limited to those we co-planned, demonstrating a vacillation in teachers' pedagogical practices between progressive constructivist approaches and formalistic approaches. Such practices are indicative of teachers' uncertainty and unfamiliarity with investigation-based pedagogies.

Another interesting finding that impacts the relevance of these pedagogies is the availability and use of teaching materials which constrain progressive learner-centred approaches to investigation-based lessons. The curriculum developers and teacher educators in this research emphasised teacher (in)competencies in utilising or improvising available resources in teaching science. Fittell's (2014) observations of Maldivian primary science teaching reported on poor utilisation of resources and categorised it as teacher incompetence and inadequacy. Similarly, Di Biase's (2019) research on LCE pedagogies in the Maldives concluded that, although there exists policies in the new curriculum to promote LCE, teachers were not capable nor were schools equipped with the resources necessary to be able to enact these progressive LCE pedagogies. In this light, Vavrus and Bartlett (2012) and Vavrus and Salema (2013) argued that in LMIC contexts, material constraints strongly determine the feasibility of certain types of pedagogies. However, these discourses wherein resources determine pedagogical viability tend to be promoted when non-locals research contexts that they cannot relate to, especially when there are no shared socio-cultural, traditional, and historical understandings between the researcher and the participants. Thus, these researchers' conclusions are based on their limited understanding and views of how and why the socio-cultural facets of the research contexts shape pedagogical practice and relevant pedagogies. Such conclusions have been helpful in understanding the terrain of pedagogies, but they have also limited our attention to one aspect of ‘relevant’ pedagogies.

As a local researcher, I could see the reverse side to this matter. As demonstrated by this research, we can see that the relevance of the resources on the pedagogical practices are far more complex than their availability or teachers’ competencies in using them. Such a focus enables us to understand how the use of resources to enhance existing pedagogies rather than using them to change pedagogical practice. In conclusion, we should focus on understanding how resources (both existing in the context and those that are being introduced) are connected to teachers’ pedagogical praxis; as a result, there exists potential to expand teachers’ pedagogical practice and praxis.

9.1.4 SPS pedagogies and the generalist teacher

This research showed how generalist primary teachers navigate the terrain of pedagogies and content that are out of their specialism. Some of these findings resonate with Ardzejewska et al. (2010), because this research also showed that teachers’ practices and engagement in SPS pedagogies are non-uniform. Dhasya and Dhalia, with their limited science knowledge and science teaching experience, implemented the investigation-based pedagogies for SPS prescriptively and superficially, while Dheena and Dhaha, with their ample science teaching experience, could easily expand their existing pedagogies to incorporate SPS into their existing science pedagogies. For Dhaha and Dheena, these changes in their pedagogical practice were within their zone of proximal development (Vygotsky, 1978) and thus their engagement, uptake, and implementation required less scaffolding to increase their engagement with more progressive aspects of these pedagogies in comparison than their other two colleagues.

These findings indicate that for generalist teachers, when teaching science out of their specialism, engagement in progressive constructivist pedagogies does not come easily. For the teachers in this study, poor content knowledge, lack of associated pedagogical knowledge, and limited experiences of diverse pedagogies, together with the ingrained traditions of formalistic pedagogies and disheartening systemic challenges, all worked in concert to create impenetrable barriers to exploring different pedagogies. Thus, this study concurs with arguments put forward by researchers such as Goodnough (2008), Childs and McNicholl (2007), Ardzejewska et al., (2010), Alexander (2011), and Steele et al. (2013), in that generalist teachers are not ideal for teaching specialised subjects in an overcrowded primary education curricula. Gordon (2009) further argued that progressive constructivist pedagogies place high demands on generalist teachers' understanding of the subject matter and pedagogical principles associated with the subject matter. The inadequate preparation of generalist primary teachers (Keil et al., 2009) and the demands of teaching across disciplines do not provide enough time for planning, reflection, and engagement with the content and the pedagogies that are required to teach specialised subjects such as science (Ango, 2002; Childs & McNicholl, 2007).

As discussed in Section 9.2.1, when teachers' ontological and epistemological views of science are different than those determined by constructivist science pedagogies or prescribed in the curriculum, the pedagogies that are relevant for the teachers take shape differently. According to Windschitl (2002), as a result of such a mismatch, teachers tend to 'choose techniques, activities, and materials that seem to fit their own styles, settings, and students, [and] then adjust them on the basis of their own goals and experience' (p. 139). As seen in this study, such 'tinkering' (p. 139) is a practical decision for teachers, resulting in a superficial application of the pedagogies that were introduced, while conservative and formalistic pedagogies remain unchanged in practice. Windschitl (2002) cautioned that such tinkering in pedagogies could be detrimental to the learning of SPS. The passivizing circumstances where teachers work does not provide professional opportunities or the means to go beyond this superficial, tinkered implementation of constructivist pedagogies to explicitly teach SPS and the content of science. The comfortable, alternative pedagogies for generalist teachers then become prescriptive teaching in validating 'textbook science'.

9.1.5 Section summary: *Towards culturally and contextually contingent constructivist pedagogies for SPS*

> Simply put, one should not expect (say) Nigerian students to understand science exactly the way students in Western countries understand science. Unless their traditional world view has been substantially altered, Nigerians will construct a view of science based on a Nigerian understanding of the nature of human beings. This does not mean they will be unscientific. Rather, their scientific viewpoint will reflect their Nigerian world view, and to that extent, there will be differences…. The problem in Non-western science education is not to make it more scientific, but to make it less culturally Western.
>
> (Cobern, 1996 p. 288)

The above quote aptly summarises the discussion in this section. Taber (2006) further argued that we as educators need to expand our understanding of learning of science in order to encompass its contingencies, including the prior learning, stability, and coherence of existing representations of scientific ideas and skills, the cognitive requirements, and the context and conditions of learning that is available for both teachers and students. This research has demonstrated what Steiner-Khamsi (2003, p.156) and later Barrett (2008, p.506) argued: when educational goods (such as pedagogies) are imported, they are resisted, modified and indigenised. In this respect, Figure 9.2 depicts the pedagogies for SPS that have been discussed in this thesis, both from literature and from the findings of this research.

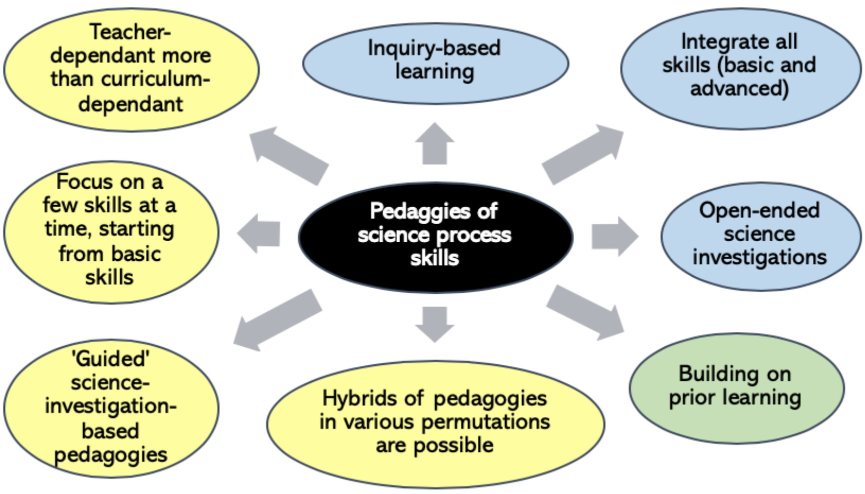

Figure 9.2 Pedagogies for science process skills.

In Figure 9.2, the features in the yellow bubbles relate to the culturally- and contextually-contingent constructivist nature of SPS pedagogies that are possible in countries such as the Maldives. Those in the blue are taken from the literature, and those in green come from the literature and findings of this study.

In summary, the terrain of SPS pedagogies is not simple to define or map. The complexities associated with how pedagogies are specified in the curriculum and how the pedagogies translate into learning experiences can result in a premature labelling of this terrain for its superficial features. However, as this research has demonstrated, there are deep, socio-culturally engrained histories and practices that shape and situate the terrain of SPS pedagogies within a unique socio-cultural context. Being a local researcher, I was able to sense and gain an understanding into how subtle yet strong forces (the legitimations discussed in Section 9.1.2), dynamic yet stubborn practices (nature of pedagogies discussed in 9.1.1), and visible yet hidden elements (discussed in Sections 9.1.3 and 9.1.4) continuously shape and weather the terrain of teachers' pedagogies.

Section 9.2 The landscape of teacher professional learning

> As learning gives rise to a multiplicity of interrelated practices, it shapes the human world as a complex landscape of practices.
>
> (Wenger, 2010, p. 182)

In the previous section, I discussed the nature of SPS pedagogies practiced by generalist primary teachers, together with the processes and tensions involved in implementing curriculum-prescribed pedagogies into their classrooms. In this section, I explore the nature and elements of TPL that shape teachers' pedagogical praxis. In so doing, I make another key argument of this thesis, **the idiosyncratic and contextually contingent nature of the micro-processes of TPL**. To make this case, below I first discuss the different types of TPL activities that were explored in this study.

9.2.1 Teacher professional learning activities and the role of the facilitator

In this section, I discuss how the different types of professional learning activities and the role of the professional development/learning facilitator shaped teachers' learning. For this, I mostly draw on findings from Phase Two (presented in Chapters 7 and 8).

It has been shown that how teachers value the different types of professional learning activities and the impact of these activities on teachers' practice is subjective. For example, all of the teachers seemed to have experienced goal-setting activities as a form of policing or evaluation of their practices. Often, in professional learning activities, goals are set collectively by the provider as reported in Timperley et al.'s (2007) meta-synthesis of science teachers' professional development research[70]. Further, as discussed in previous chapters, PD offered in the Maldives is top-down and transmissive, so goal setting as a professional learning activity was not congruent with these teachers' existing and limited palette of professional learning norms. However, the co-development of learning materials acquired different levels of interest from each participant. This interest and cooperation developed over time, with familiarity through practice and reflections in using the investigation-template. This finding demonstrates that professional learning activities need continuity to create momentum to sustain learning that is both individual and collective. As argued by professional development researchers[71], continuity in professional development and learning activities provide the time and frequency necessary for teacher learning to be meaningful for pedagogical practice. Further, continuity in learning also encourages teacher cooperation in these learning activities (Postholm, 2012). However, teacher-led classroom-research was the most impactful professional learning activity for these teachers as this activity enabled the teachers to connect their own learning to their students' learning, an important feature of professional learning highlighted by researchers such as Bishop and Denley (2007), Timperley et al. (2007), and Darling-Hammond and Richardson (2009). Such features of TPL activities and those presented in Chapter 6 resonate with similar arguments presented by Petersen and Treagust (2014), Wilson et al. (2015), and Kennedy (2016). They all argues, which I reiterate, that **TPL activities cannot be reduced to design features, nor into a 'one-size-fit-all' model,** but they should benefit from multiple modes and conceptualisations, reflect contextual contingencies, and value the diverse practices for teacher's professional and intellectual growth.

[70] They considered thirteen different research but conducted in Eurocentric countries such as the UK and the USA.

[71] Such as by Timperley et al. (2007), Cordingley, Bell, Rundell, Evans, and Curtis (2003), Earley and Porritt (2010) Darling-Hammond et al. (2017), and Loucks-Horsley et al. (2010).

This research has demonstrated the important role of the teacher professional development facilitator/provider for both teacher learning and to the development of the learning activities. The facilitator's role included bringing teachers together and promoting discussion through exploratory talk (Barnes, 2008; Wegerif, 2008). Barnes (2008) explained that exploratory talk is an 'important means of working on understanding, but learners are unlikely to embark in it unless they feel relatively at ease, free from the danger of being aggressively contradicted or made fun of' (p. 6). Thus, according to this research, the responsibility of the facilitator is to create this safe learning environment and support mechanisms through scaffolding and differentiating teachers' learning experiences of pedagogies as praxis. As such, the facilitator needs to withhold judgements on teachers' practices and provide support and encouragement when needed. Most professional development researchers agree on the importance of an external expert, yet they do not offer much on the nature of the expert's interactions beyond that of coaching or mentoring, as seen in examples from Dillon (2002), Earley and Porritt (2010), Stoll et al. (2012), and Timperley et al. (2007). Thus, this research argues that **the role of TPL provider is more than an 'external expert' that has all the answers, but they should function as a facilitator, supportively working with teachers' collective and individual strengths so that pedagogical praxis is developed in situ.**

9.2.2 The nature of professional learning: Mapping the terrain via doing, belonging, experiencing and becoming

In this sub-section, the nature of TPL is discussed and explained using the four components of Wenger's (1998) social learning theory that were explained in Chapter 3. These components are **doing** via practice, **belonging** to a community, **experiencing** for meaning, and **becoming** in developing an identity; they were discussed in Section 3.4 to theoretically frame how TPL is conceptualised in this study. In this section, I apply these theoretical components to explain this study's empirical findings related to TPL.

Professional learning comes from conscious engagement: Doing.

Dheena, Dhaha and Dhalia were engaged in their professional learning as demonstrated by their progress and follow-through in the goal setting activities. For example, when asked to reflect on the first set of goals, Dhaha expressed how she explicitly focussed on giving instructions for skills of observations and inferences, making sure she highlighted the SPS. On the other hand, Dhasya's response was uncomfortable and curt. This behaviour was typical of her participation in these learning activities, which was not as deep as the others. These aspects demonstrate that for teacher learning to be meaningful, there needs to be critical engagement in the learning process. In contrast with Eraut's (2004) claim that TPL can be implicit, this research demonstrates otherwise. TPL comes through a conscious self-awareness of *how* the learning of new ideas and concepts require changes to what they do, their classroom interactions, and the learning activities with which they engage students in, together with well-framed, cohesive and sustained activities that support such engagement (Earley & Porritt, 2010; Mitchell, 2013).

Professional learning must be of interest to the individual and the teacher community: Belonging.

In Chapter 6, I discussed how primary teachers in the Maldives were disillusioned with professional development practices and how little support they have for teaching specialised subjects such as science. In Phase Two, it was evident that while professional development and learning activities may be developed to cater to teachers' interest and relevance to classroom teaching, what teachers themselves actually find useful is highly subjective.

From an individual perspective, teachers' learning had different motivators. This created varying levels of interest for the different learning activities, form of engagement, and the classroom pedagogies that we were exploring. Dheena, as the science lead for the grade who came with a sound background in science content knowledge, was willing to explore different styles pedagogies[72] in her classroom. However, Dhalia was not as confident of her science content knowledge and teaching, but this lack-of confidence motivated her to closely follow our professional learning activities, taking extra time to study more about SPS and relevant pedagogies. For her, there was a positive feedback loop in engagement with professional learning and her interest in learning science itself. By contrast, Dhasya even from the onset was reticent to commit; she constantly mentioned the busyness of her daily schedule and presented herself as a passive participant in our collective enquiry. These individuals demonstrated varying levels and forms of belonging to the community of science teachers (Wenger, 1998).

Collectively, the groups' dynamics, interests, and commitment to the professional learning activity varied depending on the type of professional learning activities we were exploring. The group's interest also improved over time, moving from passive practices of fragmented pseudo community (Stewart, 2014; Trabona, Taylor, Klein, Munakata, & Rahman, 2019) to 'connected engagements' that were more fruitful towards a fuller learning experience. The demonstration lessons were most interesting because the teachers could experiment, role-playing as students which allowed them to see the other side of their teaching. Radford (1998) highlighted the importance of letting teachers explore new pedagogies before they teach: 'if we want students to understand the nature of scientific inquiry, teachers must have the experience of working as scientists' (p. 74). This aspect of the demonstration lesson made the teachers interested in learning the SPS pedagogies we were exploring.

These aspects highlight the nature of professional learning as both highly individual yet supported by collective practices embedded in the cultural norms of the group. The individual learning becomes conducive to collective learning and vice

[72] Such as problem-based learning (PBL).

versa (Clarke & Hollingsworth, 2002). These sources of individual input, together with the collective learning inquiry, contributed to establishing a community of learners amongst the teachers in Phase Two, where over time through these contributions together with their practices and discourses, teachers were enabled to belong to this community of science teachers. This belonging to a community promoted their pedagogical autonomy (Stoll et al., 2006) and enhanced their pedagogical praxis.

Professional learning focussed on processes and progress of learning is powerful: Experiencing.

Progression of learning is dependent on the level of engagement, together with how the teachers make meaning of this learning. This study has shown that professional learning comes from a deep, reflective engagement with pedagogical practices. This TPL is further magnified when evidence from student learning together with a supportive community work towards promoting meaningful teacher learning.

The research lessons connected teachers' own learning to their students' learning via the utilisation of SPS pedagogies. Thus, the evidence from these research lessons provided a strong learning experience that was meaningful and impactful for developing teacher's pedagogical praxis. Further, reflecting on practice that was promoted in this research, together with the goal-setting exercises, enabled teachers to monitor the progress of their own individually-driven learning. Various studies from different contexts report on similar findings where focussed teacher-research (either as action research or working as co-researchers) promote TPL in teaching science. There are examples of similar research from countries across the world, including Australia (Paige, Zeegers, Lloyd, & Roetman, 2016), USA (Zeichner, 2000), Canada (Goodnough, 2008),Turkey (Saribas & Ceyhan, 2015), Greece (Arvanitis & Chryssi, 2015), Brazil (Luguetti et al., 2019), and Pakistan (Halai, 2011) to name just a few. This substantial body of research demonstrates that despite contextual differences, when teacher learning is focussed on improving their practices, there are incremental positive changes made to pedagogical practices which are enhanced by a feeling of self-growth, and positive motivation or belief towards teaching science (Anderson, 2015).

Professional learning develops and enhances identity: Becoming.

Luguetti et al. (2018) argued that learning to teach science 'is a process of identity development… it is about choosing yourself, making deeply personal choices about who you are and who you will become as a teacher' (p. 12).

This research has shown the place of professional learning in creating and enhancing a generalist teacher's identity as a science teacher. Individual identity as well as a group's collective identity as science teachers and learners were promoted by the way teachers worked as a group in exploring science pedagogies, reflecting collectively, and familiarising themselves with the SPS and the associated pedagogies. This emerging identity was particularly evident when the group was discussing the science-investigation-based-approach of their lesson on investigating weathering. The group's in-depth engagement and reflection of the practical realties of adopting an investigation-based-approach demonstrate the individual and collective development of a science-teacher identity. Further, all of the teachers reflected on how their learning and views of conceptualising SPS had evolved to benefit future science lessons. Thus, this form of collective experimenting of pedagogies as doing and collective experimenting promote genuine learning (Kennedy, 2016) that supports the development and becoming of a science teacher.

In this vein, Barrett (2007, p. 504) distinguished between teachers' self-identity (being) and the act of teaching (doing). That distinction is significant because this research has shown that simply implementing or experimenting with pedagogies or engaging in a PD programme does not necessarily affect teachers' self-identity. This was evident for Dhasya's identity, where, although she engaged in the activities, she made little adjustment to her science teaching (and identity) because her participation was mostly passive. As Bezzina and Camilleri (2001) argued, 'teachers, in principle, may wish to take charge of things that effect their daily lives, putting this to the test is another matter' (p. 164), especially in contexts where teachers are passivized through performative practices inherent in top-down education systems. Thus, professional learning does promote teacher's identities as learners and teachers, but it requires a conscious and open mindset to learn and unlearn and to enhance and innovate teachers' pedagogies through individual and collective dialogue and experimentations. Such practices and identities give teachers agency and empowerment in their pedagogical praxis

With regard to engagement, an interesting finding from this research is how TPL is impacted by teacher's gender-based roles and their associated identities and responsibilities. All of the teachers in this research were women[73], and in particular in Phase Two, they were all mothers juggling their parenting roles with the demands of being a teacher. As discussed in Chapter 4, Maldivian societies are religiously and culturally patriarchal; thus, child-raising, cooking, and schooling matters are for mothers and women only. These additional gender-based responsibilities placed teachers' own professional learning aspirations, opportunities, and time for learning onto a back burner. Such practices seemed to have shaped teachers' existing identities as learners and teachers. Buckler (2012) reported similar findings amongst female teachers from rural sub-Saharan Africa; she pointed out a substantial gap in understanding the difference between officially valued practices for teachers and what teachers themselves value and are able to do. Such a gap is also present in the Maldives, determining teachers' identities through externally-set boundaries and expectations.

Another element of teacher identity that was demonstrated in this research is the conflict that arises when teachers' developing identities as teachers and learners clash with school's practices and norms. Dheena's conversation about unfair treatment towards her students demonstrated this conflict, where she aspired to practices consistent with her changing identity as a progressive teacher even though they were at odds with her school's traditional conservative practices. Such

[73] It is reported that there are 2.65 times more female teachers than male teachers in the primary grades (Ministry of Education & Ministry of Higher Education, 2019).

conflicting identities and practices demonstrates that Barrett's (2008) classification of individual teacher identities can be expanded to collective identities (Alexander, 2001; Wenger, 2010) within schools, highlighting the friction that can arise when identities within a community are unaligned. Thus, it can be argued that for TPL to enhance teacher practices and identities, the school's identity and practices need to develop accordingly (Adey, Hewitt, Hewitt, & Landau, 2004).

Summary of sub- section.

In this section, TPL from this research was discussed in relation to the four components of social learning theory proposed by Wenger (1998). The findings in relation to these components are summarised below in Figure 9.3, showing the dynamic and interconnected nature of how elements of professional learning, namely **individual and collective, process and product, formal and informal, contextual yet universal,** manifest in various combinations of TPL.

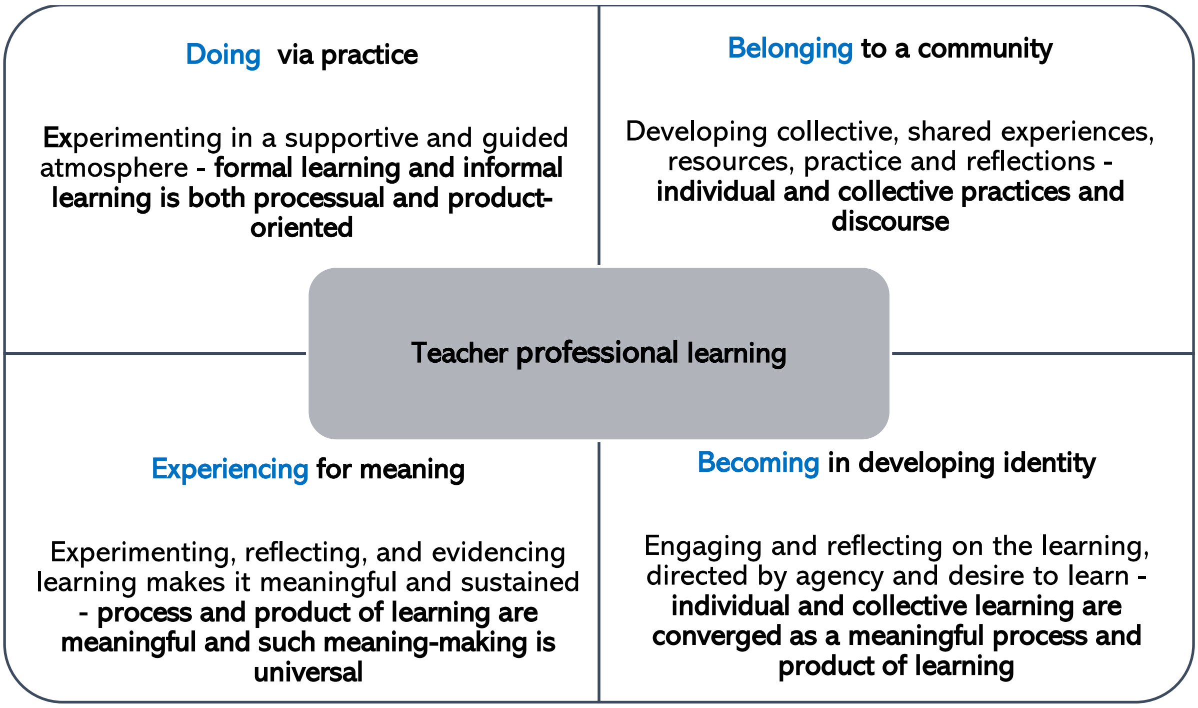

Figure 9.3 Summary of the nature of professional learning.

9.2.3 Generalist primary teachers' professional learning in science education

In Section 2.3.4, the debate around the appropriateness of generalist teachers versus specialist teachers in primary education was discussed in order to bring out two arguments relevant to this thesis. Firstly, though generalist teachers may not be the best personnel for teaching specialised subjects such as primary science, this practice is here to stay in many countries both in the global North and global South. Secondly, because of the prevalence of this practice, generalist teachers can benefit from opportunities, activities, and learning engagements that promote their content knowledge and pedagogical practices in subjects such as science.

Phase One of this study indicated that generalist primary teachers in the Maldives currently receive inadequate professional development and learning opportunities in science, despite their need and demand for it. While there exists a concerning clash between 'what teachers ought to do' and 'what teachers can practice', the professional development opportunities available to teachers have failed to address this matter because they were episodic, lacked relevance to classroom teaching, and did not support teaching science out of their areas of specialism.

These findings are important to the discussion of Phase Two of this study. In the second phase, teachers got to engage in professional learning activities that were developed based on Phase One. All the four teachers' SPS changed with the professional learning activities; their learning progressed as more time was spent on these activities. There are two noteworthy findings from Phase Two that are significant for this discussion. Firstly, these findings highlight how different teachers engage in professional learning. The professional learning was not driven by lack of content knowledge as I had presumed but by a personal and intrinsic desire to improve practice and learn. Further, what is observed in this study is in parallel with what Timperley et al. (2007) concluded: 'volunteering was not a necessary condition for successful professional development, neither was it a guarantee of change' (p. 104). Although Dheena is a generalist teacher, because of her strong science background, she engaged more actively in the professional learning activities than the other three members in the group. Dhalia and Dhasya had non-science backgrounds. However, Dhalia seemed to have an intrinsic interest to learn science and improve her science pedagogies; while Dhasya's limited science content knowledge, believed that her science teaching was sufficient within the limited accessibility of materials in her school. In this vein, Dhalia's case is similar to what Mulholland and Wallace (2000) concluded in their study with generalist teachers teaching science: non-science generalist teachers believed that supportive exposure to new pedagogies enable them to regain confidence as a science learner as well as a science teacher. However, based on Dhasya's case, it is evident that, for pedagogies to impact non-science generalist teachers' pedagogical praxis, teachers need to be open to professional learning, and they need to be ready to engage in learning opportunities for their professional growth.

The second finding comes from this clash and my presumptions around it. Stakeholders such as curriculum developers and teacher educators believed that 'teachers ought to practice' what was learnt in pre-service training; through this (limited) training, teachers should have enough competence and confidence to interpret the curriculum. They also believed in constructivist pedagogies aligned with progressive education ideals as the 'best' pedagogies for teaching science in Maldivian primary classrooms. Anything less was used to perpetuate a blame game and pejorative discourse. These were my own sentiments prior to this research.

However, TPL findings from this research indicate that these expectations and the practices of pre-service education maybe suitable for preparing a specialist science teacher but serve to limit the development of a generalist teacher. Mulholland and Wallace (2003) made similar observations, arguing that teacher educators and professional development providers assume generalist classrooms and teachers have the capacity, resources, and time to practice these progressive pedagogies that promote open exploration, hands-on science, and use of science-talk in the classroom. This research shows that such placing such expectations upon generalist teachers is unrealistic and perpetuates a pejorative discourse around generalist teachers' realities. Stakeholder expectations on teachers set prejudices that need to be curbed in order to provide meaningful, supportive, and truly genuine learning experiences for teachers, develop experiences which promote teacher autonomy and professionalism in teaching science.

9.2.4 Section summary

In this section, I have discussed the nature of the professional learning activities and the outcomes of these activities in relation to the research. The learning activities designed in this research have utilised features of constructivist learning theories and social learning theories to develop science content knowledge and application of these pedagogies. For both, there is a critical focus on learning, and the nature of learning that incorporate individual, collective and contextual contingencies. Further, I have also argued that learning is a gradual, developing process that happens both within organised, formal activities as well as within impromptu informal activities.

These findings demonstrate that teachers' professional learning is determined by **interactions** between **collective**, **individual,** and **contextual** elements. Conscious actions of reflection, experimentations, discussions, and co-developing materials demonstrate the processual nature of professional learning. For professional learning to be meaningful, these interactions play a critical role in connecting individual learning, collective learning and the contextual nature of teachers' learning. In this sense, individual learning is about the cognitive processes of the individual together with the practices they engage in. The collective learning context situates these learnings within a community of practice, promoting learning through processes such as dialogue and the development of artefacts such as teaching resources that are meaningful within collective practices. Further, contextual learning situates and shapes further learning trajectories. As demonstrated by this research, contextual learning could have a positive impact, for example in maintaining a supportive and conducive learning experience. Conversely, the context could also have a negative impact on learning, for example when systemic issues hinder learning opportunities. The freedom to navigate oneself from, between, and in these elements (individual learning, collective learning, contextual learning) promotes the form of democratic professionalism discussed in Chapter 3.

Conclusion: Building roads to travel

There were three key arguments discussed in this chapter, building towards the tenets of this thesis. **Firstly, generalist primary teachers' pedagogies for science process skills are limited due to their narrow conceptual and procedural understanding of science and they practice culturally-contingent constructivist pedagogies, a combination of constructivist pedagogies and formalistic pedagogies.** Teachers' adoption of progressive learning methods (for example, inquiry-based learning) is highly determined by their confidence and active engagement in understanding the nature of science as a pedagogy of science. When teachers are less confident in the science content they are teaching, they opt for more formalistic features of constructivist pedagogies for SPS. In contrast, when teachers are confident in the science knowledge and skills they are teaching, they practice more progressive elements of SPS pedagogies while those in the middle demonstrate hybridised pedagogies determined by practicality.

Secondly, TPL is a complex phenomenon that is contextually contingent with features of individual and collective learning. Any professional learning engagement with teachers that focusses on their pedagogical praxis has to consider the processual and progressive nature of professional learning as shaped by learning that is both formal and informal, and as situated within the continuum of learning.

Thirdly, when teachers engage in professional learning that explores their pedagogical practices and moves rhetoric and discourse to pedagogical praxis, their learning is more meaningful, empowering, and strongly connected to, and reinforced by, their students' learning.

Further, while professional learning approaches need to reflect pedagogies that are being promoted, in the design of both professional learning and pedagogies we need to be mindful of what is possible within the educational contexts and settings. This research has shown how professional learning and pedagogies are intricately connected and contextually contingent. When professional learning is set up within and centred around the explorations and engagement of teachers' pedagogical possibilities, the resultant professional learning and pedagogy practices are relevant, purposeful, and meaningful to both teachers and learners. Thus, TPL practices have to support and empower teachers' mapping and navigating of their individual and collective pedagogical terrains; TPL should enable them to build roads of teacher professionalism with resources, tools and learning experiences that are unique to individuals and yet respectful to the socio-cultural elements of their contexts.

Based on these findings, in the next chapter, I provide answers to the research questions of this study, highlighting how these answers contribute to the broader fields of teacher professional development and learning, and SPS pedagogies.

Chapter 10. Conclusions and Implications

You have learnt and stored up the knowledge from strangers,
And polished your face with their rouge;
You borrowed luck from their ways
Till I know not whether you are yourself of someone else!
Your mind is chained to their ideas;
The very breath in your throat plays on the strings of others,
Borrowed converse pours from your lips,
Borrowed desires nestle in your heart!
How long this circling round the assembly's fire?
An individual becomes unique through self-realization.
A nation becomes truly itself when it does not compromise

(From Sir Allamah Muhammad Iqbal's *Rumuz-e-Bekhudi*[74] 1918, p. 186-188)

Introduction

In this chapter, I conclude this thesis by providing the implications of this research, presenting the contributions, and reflecting on my overall learning. To do so, first, in Section 10.1, I summarise the findings to answer the research questions. Following this, in Section 10.2, I present implications for practitioners such as teachers, teacher educators, and curriculum developers. In Section 10.3, I recommend how the findings from this study can be informed to enhance practice and policies. Though these are implications directly applicable to the Maldives, other contexts similar to the Maldives could benefit as well. In Section 10.4, I offer the contributions from this study, and in Sections 10.5 10.6, I identify the limitations of this study and suggest priorities for future research, respectively. Finally, the thesis is brought to a close with a forward-looking note as I reflect on my personal and professional development as facilitated through this research process.

[74] Translated as 'The Secrets of Selflessness', is a philosophical poetry book written in Urdu. I have provided here the translations by Saiyidain, 1945, p. 35.

Section 10.1 Summary of findings

This research aimed to explore upper primary teachers' professional learning of pedagogies for science process skills (SPS). The findings are summarised below mapped as answers to the research questions of this study.

RQ 1. How do primary teachers in the Maldives conceptualise and support their students to develop science process skills and its pedagogies?

Generalist primary teachers' conceptualisations and application of SPS in their science teaching are limited to basic SPS. While these teachers practice various pedagogies rooted in constructivist learning theories of science teaching, their limited pedagogical palette and the systemic challenges, together with socio-cultural norms and practices in their schools, limits the opportunities teachers offer their students to develop SPS. Consequently, the pedagogical practice of primary teachers can be characterised as prescriptive, formalistic pedagogies which promote performative science learning experiences.

RQ 2.What pedagogies for science process skills are possible and meaningful for primary teachers in the Maldives?

There exists a spectrum of pedagogical practices for SPS that are possible and meaningful for generalist primary teachers in the Maldives. These pedagogies range from formalistic traditional pedagogies to progressive, constructivist pedagogies; various combinations of these forms are also possible. These pedagogical choices and practices are determined and limited by barriers that are both at the system level and the socio-cultural level. The systemic barriers include the nature of the education system in the Maldives with its rigid top-down hierarchy of communication and policy practices, teachers' limited opportunities and options for innovations within continuing professional development, and the limited resources available for various pedagogical innovations. Barriers at the socio-cultural level include the pedagogical traditions of formalistic Islamic education that is prevalent in the country, the performativity and competitive school culture that is revered by parents and the Maldivian society at large, and a continuous seeking and dependence on foreign expertise for local problems. Further, for generalist teachers, their professional competences and views of teaching science also play a significant role in shaping their SPS pedagogies.

When teachers are confident in their science content and associated SPS pedagogies, their classroom practice reflects strong elements of science-investigation-based-approaches (SIBA) that integrate these skills with the content. Teachers with limited science content knowledge and lessened confidence in science teaching tend to hybridise constructivist pedagogies with formalistic pedagogies, depending on their understanding of the science content and the associated SPS. However, there are also teachers who practice predominantly formalistic pedagogies for SPS, a choice often determined by their limited understanding of science and SPS, limited resources, and the incessant push they feel to implement and 'complete' an overcrowded primary curriculum. Thus, teachers with sound science content knowledge tend to employ progressive constructivist pedagogies more often, while those that are open to innovative pedagogies and motivated to learn can hybridise their existing pedagogies with innovative (progressive) pedagogies. For those teachers, whose science content knowledge limits their confidence, they tend to seek this confidence through authoritative formalistic pedagogies.

Despite these different pedagogical practices, collective pedagogical inquiries within school communities can provide meaningful pedagogical praxis that expands teachers' pedagogic repertoire from teaching basic SPS to teaching integrated SPS. Further, using the science-investigation-based-approach (SIBA) to teach SPS offers a flexible, meaningful, and culturally contingent constructivist pedagogical approach for generalist teachers to teach SPS in their preferred pedagogical styles.

RQ 3. How can a professional learning inquiry engage primary teachers in exploring and enhancing their pedagogies for science process skills?

Professional learning opportunities and activities have to be designed for schools, teachers, and the nature of the subject matter they are teaching. The process of learning these activities must make connections to teachers' practices and offer multiple and sustained opportunities to experiment with pedagogies collectively and individually while creating safe and collegial spaces for reflection. Further, using evidence from students' learning for the purposes of professional learning makes a great impact on teachers' motivations and engagement in collective and individual professional learning inquiries. Moreover, when these practices are embedded in teachers' professional lives through situational and meaningful learning experiences, we can promote democratic teacher professionalism that empowers teachers in their pedagogical decision-making. Finally, TPL is complex and features such as individuality, community, formal and informal learning, and processual learning are important to make it contextually- and situationally-contingent for teachers. Although these features may be inherent in any professional learning inquiry, as demonstrated by this study, the flexibility in how these features are integrated into a professional learning engagement is critical for promoting teachers' professional learning.

Section 10.2 Implications for practice

In this section I draw out implications from this study for teachers, teacher educators, curriculum developers and school leaders in their roles as innovators of pedagogies and influencers of curriculum.

The findings from this study have direct implications for teachers' practices of SPS pedagogies and teacher professional development and learning. Pedagogies for SPS need cannot be driven only by what the curriculum specifies, but must respond to students' learning needs and are shaped by teachers' pedagogic repertoire. We need to understand that the SPS specified in the curriculum can be implemented in the classroom using a variety of pedagogies, and the nature of these pedagogies does not have to be dictated by foreign sources nor by popular global pedagogies. Further, teachers are responsible to engage themselves with these pedagogical discourses via professional learning practices that explore pedagogical possibilities and compatibilities or hybrids between their existing pedagogies with innovations; the task for practitioners is not about blindly changing practices nor discarding existing practices, but to enhance repertoires of pedagogical praxis to better understand and enhance existing pedagogical practices.

Furthermore, teachers, such as those in this research, are in position to provide evidence from their classrooms on pedagogic possibilities for stakeholders, highlighting the (in)congruences between the curriculum-specified pedagogies and those teachers can practice. While there are systemic challenges for teachers to directly provide such evidence to stakeholders, the collective teachers' voices in the society can be used to advocate for such evidence-based policy making. Various platforms such as education conferences, social media and teacher networks can be used provide this evidence for stakeholders. Thus, through teachers' practice of SPS pedagogies and TPL teachers can challenge the popular rhetoric of a standard 'best practice' in education and the underlying progressive LCE practices (Crossley, 2019; Schweisfurth & Elliott, 2019).

This study's findings also have some implications for pre-service and in-service teacher education practices. The most critical implication is to provide continuity in the pedagogies advocated through these teacher education mechanisms so that there is a continued, sustained, and concerted support *for teachers* and *with teachers* in developing their pedagogical praxis. Such practices will promote democratic teacher professionalism. Further, such mechanisms and practices will also enable the development of professional networks of educational practitioners where information is bidirectional, unlike the existing one-way conduit promoting discourses of teacher-as-deficit. Furthermore, pre-service and in-service teacher professional development need to develop their programmes in conjunction with evidence from classroom realities that capitalise upon pedagogies that are possible in the Maldivian classrooms, rather than focussing on some utopian practices promoted by donor bodies or powerful international organisations with their ‘reference societies’ (Sellar & Lingard, 2013).

For teacher educators in the Maldives, the pre-service curriculum and in-service teacher development activities they conduct must reflect teachers’ realities rather than on aspirations based on some Western education context. This research has illuminated these possible pedagogies. In the pre-service teacher education curriculum, units on teaching and learning science, teaching practicum, and science content need to reflect these pedagogical realities that are possible in the Maldives. Such practices of focussing on possible pedagogies will strengthen the pre-service education system without wasting time, resources, and effort to reproduce foreign education systems and practices. As such, teacher educators need to move away from the pejorative discourses that view teachers-in-deficit. They also need to move from the rhetoric of ‘This is how things are done in UK/Australia/New Zealand, where I did my undergraduate/masters, so we need to do the same in the Maldives’ in order to see compatibilities of pedagogies and professional learning practices that are viable in the Maldivian context. The poem quoted at the beginning of this chapter argues against such idolisation and uncritical borrowing of practices from the West. As Akyeampong et al. (2013) write, ‘teacher education should be reconstructed as a study of classroom practice that places children’s learning at its centre’ (p. 272), but it is also important to bring teacher learning and development to the forefront of teacher education. Such changes will come through open communication *with* teachers and participatory research *with* teachers that valorises teachers' practices, experiences, and professional lives. Within the education system in the Maldives, the teacher educators have enough power to bring about these changes through their practice.

School leaders are also in a place to promote professional learning approaches that promote democratic teacher professionalism. School-level policies need to consider teachers' realities, practices, and needs for professional development and learning, rather than focussing exclusively on performativity practices. School leaders can formulate school practices that foster teachers' professionalism through setting up communities of professional learning where the focus is on pedagogical praxis and collecting evidence around students' learning, teacher learning, and teacher reflections. Further, school leaders need to promote practices that encourage and support teachers to develop their teaching and learning resources and share them in their communities of teachers within and across schools.

Science education in the Maldives needs to look at developing students' science learning experiences based on our local environment and familiar pedagogies. The Maldives do need scientifically-literate citizenry to mitigate the ongoing climate change challenges we face, and to educate our future citizenry based on these lived realities. We also need pedagogies that are close to our social, cultural, and historical context. Such science education may require traditional conservative pedagogies or contingent constructivist pedagogies. It is the science education community in the Maldives who can understand the socio-cultural and pedagogical contexts of the Maldives and hence are in a better position to develop and promote contingent pedagogies to nurture learners' scientific curiosity. Such pedagogical experiences can also be useful for developing TPL practices in science education. As such, as LMICs and SIDS we do not have to completely rely on external donors and experts to provide us with science teaching resources and pedagogies. Rather we can develop our contextually-sensitive pedagogies for learning science, using the resources in our unique environment, whilst engaging in TPL mechanisms that are relevant for such pedagogical praxis. Further, as this research has demonstrated we can use a constructivist mode of SPS pedagogy, such as the SIBA, yet use it flexibly. As Crossley (2019) and Louisy (2011) argue, local teachers and practitioners are best placed to understand local socio-cultural practices, as well as priorities and possibilities for developing these practices. Thus, the science education community in the Maldives would benefit from networking with similar LMICs and SIDS for contextually relevant science education pedagogical support and development rather than simply and uncritically importing pedagogies from the wealthy, developed and industrialised Western countries.

Section 10.3 Implications for policy

Supporting successful pedagogical and professional development practices require a systemic and concerted response from policymakers and policy implementors. As Crossley (2019) argues, one way to do this, especially in SIDS and LMICS is to consider evidence from practice that does not marginalise democratic voices from the practitioners. Policymakers at the Ministry of Education (MoE) need to consider such evidence when identifying SPS pedagogies and formulating PD policies to promote democratic teacher professionalism practices that are culturally sensitive and contextually congruent. As such, similar to those arguments presented by comparative researchers such as Crossley (2010, 2019), Louisy (2011, 2018) and Sriprakash (2012), I argue that policies should be formulated to enhance existing practices rather than to replace them, so that we can move away from uncritically borrowing policies that are made elsewhere. To do so in education policy formulation and implementation, we need to consider our local, contextual and socio-cultural needs and sensitivities in education, yet be mindful of international and global discourses and agendas that affect the education sector. One way to do this is to develop a ‘bricolage’ of policies that are informed by both the local needs and global agendas, yet demonstrating agency of local policies (Crossley, 2019). Further, policymakers need to also understand that it is not local policy development and implementation we need to consider, but also to identify and explore the implications for contextually-appropriate responses at a local level to those policy initiatives that are externally set (Crossley, 2019; Crossley & Louisy, 2019; Louisy, 2011, 2014).

A more specific implication for policy is at the broader level of the Maldivian education system level. It involves both an immediate action and a long-term action. The immediate action relates to the arrangement of generalist primary teachers. While this may be a practice common in countries that the Maldives idolises, the Maldivian education system needs to look at how such an arrangement is affecting teachers’ practices and morale, along with students’ learning. As findings from this research show, generalist teachers are struggling to teach science, regardless of the pedagogies they are using. We must be content with formalistic approaches for teaching science by generalist primary teachers, and, if we are not, we need to provide mechanisms so that we have specialist or semi-specialist teachers for primary science. Thus, asking teachers to use progressive constructivist pedagogies to teach a subject that they are unable to comprehend themselves is unprofessional and unjust. However, as the research shows, most schools in the Maldives have a specialised science teacher at each grade, who currently are only seen and practising as 'grade subject lead'. Instead, these teachers could play a more active role in mentoring, coaching, or team-teaching non-science-specialist generalist teachers. Thus, more time for teacher collaborations that focus on pedagogical inquiries can be established. Further, though offered for the context of England, Alexander's (2011) suggestion for more flexibility in primary schools staffing where a mix of a generalist, semi-specialist, and specialist teachers who can work together, support each other, and build professional partnerships, could be valuable to the Maldivian context, because currently in the Maldivian primary schools these variations in specialisations exist, but their expertise to contribute to the collective pedagogies are not acknowledged. Such professional arrangements can be implemented immediately through policy imperatives.

The long-term implications are to allow more freedom and choices to schools around their pedagogic practices and professional development, in order to establish school level professional learning communities. As seen from this research, individual teachers' pedagogical practices and professional learning are subjective. Similarly, these practices would also be unique and subjective for individual schools. Thus, the MoE needs to move away from imposing rigidly defined common standards and expectations on schools that supresses teachers' pedagogic innovations. In so doing, MoE can provide schools flexibility and freedom for making curricular choices, thereby providing teachers more autonomy and agency in their professional practices. This move would value the expertise of teachers in providing school-based professional development and learning by establishing pedagogical praxis within their school communities. Thus, MoE needs to valorise such local expertise over the offerings of external, foreign expertise in decisions affecting the professional practices of schools.

Curriculum developers and other policymakers need to move away from uncritically borrowing pedagogies and curriculum policies from other 'reference societies' (Sellar & Lingard, 2013). Although curriculum developers may be removed from classroom realities to directly understand issues that arise with uncritical transfer of pedagogical ideas, curriculum development can be informed by teachers' practices, expertise, and voices to understand the pedagogies that work for subjects such as science. Rather than relying on implementing internationally travelling education policies such as LCE, curriculum developers and policymakers need to use evidence from within the country itself to inform policymaking and curriculum development, reflecting our local and contextual needs and sensitivities (Crossley, 2019) in science education. As such, teachers need to be given freedom, choice, and empowerment in their professional decision-making. Specifically, teachers need freedom from constant policy requirements imposed in a top-down bureaucratic way giving teachers limited choice in how they prepare for their classrooms. Teachers need freedom from having to constantly collect and submit performance data in new formats forcing them to spend more time counting the outcomes from their teaching, rather than reflexively working to change those outcomes in ways that respond to the needs of their students. Teachers need time within the school day for collaboration with colleagues given that the majority of primary school teachers in the Maldives are women who work in the 'double shift' of home-care responsibilities and work. Such mechanism in the school and the education system at large will support and encourage teacher's professional growth.

Currently, in the Maldives, although there exists a formal teachers' professional association (Teachers' Association of Maldives), it has limited power and voice in the policymaking platform. This association is of value in changing practices of pedagogies and professional learning to claim space and 'political power' within the education system because they represent the collective voices and experiences of teachers in the Maldives. Thus, this body can act as the bridge between policymakers and teachers advocating for evidence-based policymaking, where evidence is centred around teachers' classroom practices and realities (Gutierez, 2016; Hattie, 2003). Such teacher empowerment can only be possible if policymakers democratically share the decision-making platform with teachers.

Section 10.4 Contributions to academic debate

In this section, the substantive and methodological contributions from this research are presented.

10.4.1 Substantive contributions

This study contributes to the broader field of science education and teacher professional development and learning, providing a rich contextual understanding of generalist primary teachers' journeys and trajectories of professional learning in adapting/adopting pedagogies for SPS in the small-island-developing state of the Maldives, classified as an LMIC. In the context of the Maldives, research on teachers' professional development and pedagogies is scarce and even rarer in science education. Thus, this research provides an in-depth understanding of the nature of professional learning, the process of adopting/adapting pedagogical innovations, and how in tandem they both operate in schools within the elements of a broader community of practice (Wenger, 2010). Through the findings, I contribute a more rigorous and humane way of looking at TPL, focussing on pedagogical praxis as a form of professional learning. I explain below these specific substantive contributions from this thesis.

Pedagogical practice and processes

This research has provided insights onto pedagogies for SPS that are currently practised and have the potential for being practised in the Maldives. Figure 9.1 offers a nuanced view on how curriculum prescribed pedagogies enter the classroom, re-focussing our attention on the micro-processes involved in these dimensions (pedagogy as prescribed, pedagogy as enacted and pedagogy as experienced). Thus, we can re-conceptualise these dimensions as processes rather than products, to understand how teachers' pedagogical practices are shaped by the ontological and epistemological boundaries set by each of these dimensions, and eventually on their professionalism. As such, this study has expanded Nind et al.'s (2016) conceptualisation of pedagogical dimensions to incorporate a view of pedagogies as practices and processual, while highlighting how each of these dimensions plays a role in legitimising certain types of pedagogical practices. Additionally, this study has also expanded on studies by Di Biase (2016, 2017, 2019) on pedagogies in the Maldives, to further argue that in SIDS and LMIC contexts of top-down education systems, where external agencies promulgate a discourse of best-practice, pedagogical practices that are available for teachers are limited, rigid, and experienced by teachers as de-professionalising. In doing so, this study builds on broader studies on pedagogies that advocate for its contextual contingencies (Schweisfurth & Elliott, 2019; Sriprakash, 2012).

Science process skills pedagogies

This study has expanded pedagogies for SPS through its contextually-rich findings on teachers' practices in an authoritative and dictatorial education system within which passivise generalist teachers are pushed beyond their capabilities to implement an overcrowded curriculum. As such, while reports on the successful implementation of progressive pedagogies have been reported in a few schools in the Maldives (see Di Biase, 2016, 2017, 2019), this study has explored SPS pedagogies relevant to teaching primary science. In doing so, this study expands on SPS pedagogies through its use of SIBA pedagogies as a mechanism to teach science process skills through constructivist pedagogies. Further, this study adds to the body of previous research that calls for non-Westernised science education (e.g. Asabere-Ameyaw et al. (2012), Cohen, (1998), Le Grange (2007), and Tikly (2019)).

Furthermore, through this study I argue that SPS pedagogies cannot be simplified into hybrids of progressive and conservative pedagogies as the only possible way forward. Similarly, it cannot be simplified to narrow reporting of SPS pedagogies as reflecting formalistic conservative/traditional approaches, either. As such, this research contributes to discourses on pedagogies, especially SPS pedagogies to argue that **all these possibilities and variants of SPS pedagogies, in fact, co-exist** in the Maldivian education system and especially in one subject area, thereby building on similar arguments made by Barrett (2007) and Sriprakash (2010, 2012) regarding acknowledging hybrid pedagogies and Guthrie (2011, 2018, 2020) who argues for traditional formalistic pedagogies that are socio-culturally sensitive to the context. Congruent to Tikly's (2019) argument, this study too, has demonstrated the importance of valorising the multiplicities of pedagogical practice in LMIC contexts. Thus, this study contributes to the advocacy of SPS pedagogies that are contextually-contingent within the constructivist pedagogical practices for teaching SPS, where SIBA is such an example.

Teacher professional learning

An important contribution from this research is building on the evidence base and literature that argues for a connection between pedagogies and teacher professional development. While authors such as Stoll, Harris, and Handscomb (2012) and Barrett et al. (in press) have advocated for such a connection, this study expands on this by arguing on the importance of this connection for generalist teachers teaching outside their specialism. Additionally, this study expands on TPL literature that argues for constructing models and features of effective professional learning to argue that teacher PD initiatives, including the one reported in this study, cannot be simplified into glowing reports of successful 'fragile beginnings' that ignore alternative and existing practices considering the fluidity and dynamics associated with situated professional learning practices.

For TPL practices, this research contributes towards understanding its nature of the micro-processes (such as developing lessons, implementing, reflecting) through which individual teachers engage and make meaning from professional development activities to expand their pedagogic repertoire. This study adds to the literature base that conceptualise teacher professional development as professional learning. According to Mitchell (2013), Bishop and Denley (2007) and Handscomb (2019) professional learning is meaningful when connected with teachers' classroom practices and evidence from it. This study has expanded these conceptualisations to demonstrate the multifacetedness of TPL and so offer a more nuanced understanding that can inform the design of such TPL activities, especially within SIDS and LMIC contexts. As has been demonstrated by this study, we can develop world-class learning mechanisms, but how teachers use them, engage in them, and learn from them is highly subjective; thus, TPL offerings need to cater to these subjectivities.

Finally, this study also contributes to the broader literature on TPL by arguing that educators and professional development providers need to facilitate the subjective individualities in professional learning while promoting collective learning as communities of learners (Wenger 1998) and democratic professionalism (Evans, 2014) practices, and this can be offered through **a contextually contingent approaches for professional learning**. The explanations and understandings offered in Figure 9.3 regarding the mechanism through which teachers engage in professional learning (such as teachers' practice, make meaning of, and develop their identity as community of learners), stand to expand our understanding of TPL. In this study, this understanding was possible via the application of social learning theory (Wenger 1998) to teacher professional learning; thus, such a theoretical exploration could benefit professional development providers and academics from similar contexts.

10.4.2 Methodological contribution

Methodologically, this research significantly contributes to researching in small states context and participatory methodologies in teacher research. These contributions are explained below.

Researching in small states contexts

As Crossley (2010, 2019) and Guthrie (2015a) advocate, researching in small states context requires contextually sensitive research methodologies, practices and attitudes. This research expands on this notion by building on methodological approaches of researcher positionality and navigating issues arising from the 'smallness' typical of small states contexts.

This study contributes to the broader literature base on positionality in comparative and international research in education. Crossley, Arthur, & Mcness (2016), Milligan (2016) and Mcness et al. (2015) have argued about the complexities of research positionality and the need to continually negotiate this with the participants. This study builds on these arguments by highlighting the intensification of such complexities and thus the need for continious (re)negotiating of researcher positionality when researching in small states. Furthermore, this study expands the conceptualisation of positionality beyond the insider-outsider continuum (Milligan, 2016), building on a socio-constructivist epistemology of positionality (Mcness et al., 2015), that is multi-dimensional, temporal and heavily shaped by the nature of the research itself. For example, participatory research as applied in this study has necessitated a constant attention to reflexivity, to accept positionality as subjective, and in continuous flux, yet determined by the socio-cultural norms and practices of the participants.

Educational research conducted in small states in the Caribbean (Crossley & Louisy, 2019; Louisy, 2014, 2018), the Pacific (Guthrie, 2015b, 2015a) and in the Maldives in (Di Biase, 2016, 2017, 2019; Moosa, 2013) and collectively across small states (Crossley, 2019; Crossley et al., 2011) argues that the smallness of these countries and their communities bring about unique methodological considerations. This study expands on these methodological considerations by highlighting two elements crucial to researching in small states. Firstly, it is imperative to consider and be reflexive about the relationships between the researcher and the context, because the 'smallness' of these research communities (Moosa, 2013) together with their insularities and associated transparencies (Di Biase, 2016, 2017, 2019) brings about numerous methodological dilemmas for the researcher. These dilemmas are critical to access the contextual and socio-cultural sensitivities that are unique to these contexts. The detailed findings of this research were possible because of the lived experiences and contextual knowledge shared between the teachers and me as the researcher and the way this common knowledge was used to develop researcher-participant relationships. Secondly, in researching into LMIC and SIDS contexts, local researchers must play a key role because their involvement allows access to valuable, contextually-situated knowledge enabling significant insights that are much richer than that which an external researcher may be able to tap into.

Researching teacher professional learning

In exploring teacher professional learning (TPL), this research has offered a more collaborative and up-close methodological approach whereby the professional learning activities have the dual purpose of research data as well as the mechanisms for teacher learning. As such, this research expands on participatory teacher-research methodologies (Check & Schutt, 2011; Cochran-Smith & Lytle, 1999; Zonne, 2007), with a battery of data collection tools that also serves as TPL activities. These methods offer TPL researchers a way to work alongside the teachers, engage in their classroom practices, and participate in collective curriculum planning at the school-level. Such methods enabled me as a researcher to centre TPL on classroom practices and through interviews and use of narratives to offer an 'up-close and personal' account of individual teachers' professional learning as they experienced or articulated it. Further, these methods also offered flexibility to make contextual contingencies in researching TPL. Specifically, this study contributes to this broader methodology by demonstrating the intrinsic value of using data collection methods that value teachers' expertise in determining their professional learning and in turn the research trajectories.

This study also contributes to participatory teacher research methodologies. The way this study has applied sequential and supplementary phases of data collection and analysis adds on to the existing methodologies of researching TPL. In particular, the use of a 'baseline' phase followed by an explorative intervention phase, a common approach in TPL studies, stands to argue on the importance and relevance of these methodologies to explore teacher learning in contexts such as the Maldives. Finally, this research has also demonstrated how participatory teacher research methodologies promote researcher reflexivity that develops researcher's professional learning alongside that of the participants'. These contributions enhance the range of methodologies that can be used to study teacher professional development and learning as situated within the teachers' practice; methodologies that foregrounds teachers' voices, agencies and professionalism in education research.

Section 10.5 Limitations of the study

Overall, the present research is valuable in providing rich contextual details about the nature of practices pertinent to SPS pedagogies and teacher professional development and learning. As this research is situational and contextual and by the nature of the qualitative research design I have employed in this study, I do not seek generalisability nor representativeness of the findings from this research for application to other contexts. However, because I am aware that the readership of this thesis could potentially be policymakers and science teacher educators, I identify here some limitations to extrapolation of the findings from this study.

Firstly, the study only focussed on generalist primary teachers' pedagogies for teaching SPS, narrowing the focus on their pedagogical practice in one subject. As such, only teachers within Key Stage 2 (grade 5 in Phase One and grade 6 in Phase Two) were considered. Grade 4 is also part of this Key Stage and perhaps including them in this study would have deepened the richness of the teacher narratives and provided more insight into SPS pedagogies and teacher professional development and learning. Similarly, including teachers from Key Stage 1 might also provide deeper insights into their practices.

Secondly, though female teachers represent the majority of primary teachers in the Maldives, and all the participants in this research are female, it would have been valuable to contrast female teachers' experiences with those of their male counterparts to explore gendered patterns that inhibit participation in professional learning practices and views. Similarly, it would have also been meaningful to consider the discourses of teacher educators from different teacher education institutions and various professional development providers, to understand how they situate their roles in teacher education. Comparing these views with my current views of teacher education and the role(s) of external facilitators in teacher professional development will provide valuable insights on the context of teacher professional development in the Maldives.

Thirdly, though this research uses a participatory methodology, due to time constraints, I could not use participatory approaches in the research design, data analysis, or interpretations. Involving teachers in all these elements would have provided more meaningful research interpretations that teachers could directly relate to and implement in practice. For this reason, it would have been interesting to compare practices of primary school teachers in other locations in the Maldives to explore how they manage professional learning for SPS pedagogies and to identify what limitations and challenges exist for their professionalism.

Fourthly, the theories that I have applied for pedagogies and professional development and learning were based on my limited exposure and preferences to these theories. In particular, using social learning theories for professional learning was a choice I made due my familiarity with this theory. Perhaps using other theoretical lenses or models of professional learning could have provided a different focus, bringing in perhaps interesting and alternative conclusions.

Finally, I also acknowledge that I had started this research with a different perception about teachers, the research problem, and the potential research design I would be using. Reflecting and looking back, I am aware that I would have approached this research differently now, with my newly gained insights. These aspects had limited the options I was aware of and able to use at each aspect of the research. For example, in Phase One, I was very much driven by the fact I had wanting to identify a gap between the teachers' practice and what was prescribed in the curriculum, without an alternative way to view such a gap. However, if Phase One was attempted with a broader and wider understanding (an understanding I was able to arrive at towards the end of this study) of teachers' SPS pedagogical praxis, TPL practices, research positionalities and possibilities, perhaps a richer and more in-depth picture of teachers' practices could have been explored. Similarly, with such a mindset in the design and implementation of the TPL activities, a wider range of flexible choices that are more contextually-situated could have been explored. Lastly, because of my limited understanding prior to this research, I had started this research focussing on an output, (a pedagogic approach), but through the research process my focus has shifted towards the processes of teachers' professional learning and its importance for pedagogic innovations.

Section 10.6 Directions for future research

The findings of this research in light of the previously discussed limitations offer rich avenues for further research. Firstly, researching into teachers' pedagogies across broader subject areas, involving teachers with different backgrounds, genders, and experiences will enable us to expand on the findings from the current study. Secondly, future research needs to engage stakeholders in the research itself through participatory research approaches so that their views and practices on teachers' expertise could be studied and expanded alongside that of teachers, creating a more supportive and professional atmosphere in education sector. Similarly, it would be very useful and interesting to conduct a more comprehensive participatory research with teachers to explore pedagogies through TPL, while incorporating a broader participation from teachers, curriculum developers and teacher educators.

Thirdly, similar research in other school contexts, island contexts, or other similar LMICs and SIDS contexts would be interesting to see, so that cross-country comparisons would bring in a richer and deeper layer of analysis to understand teachers' practices across similar countries. Finally, it would be valuable to conduct longitudinal research which follows teachers through pre-service to in-service teacher education to understand the continuity in teacher development but also how teachers' professional learning develops across different forms of teacher education and into their professional careers.

Section 10.7 Epilogue

> "Who are YOU?" said the Caterpillar. This was not an encouraging opening for a conversation.
>
> Alice replied, rather shyly, "I–I hardly know, sir, just at present– at least I know who I WAS when I got up this morning, but I think I must have been changed several times since then.
>
> (Lewis Carrol's *Alice's Adventures in Wonderland*, 1865)

Similar to Alice, I knew who I was on the day I started this journey, as I got onto an aeroplane, heading to the UK. Since then, I have changed, grown or rather metamorphosed. Unlike Alice though, I do know a bit about who and what I am now because I have reflected on the personal and professional growth this PhD process have brought me. Experiencing this PhD process took me on a journey of self-discovery into ways of being and becoming and ways of thought and thinking which otherwise would not have been possible. This PhD process has forced me to reflect on the 40 years of my life; my upbringing, formative schooling, teenage years, beginnings of my professional career, and mothering, all the way to where I am today. These reflections have made me understand how all these experiences have collectively influenced my thinking and worldviews. While I do not want to judge my humble efforts on the thesis as a product of my PhD experiences, I am proud of how this journey has shaped me into a researcher. At the end of this PhD journey, as I head home to the Maldives, I identify here some of the significant learnings and fascinations from this journey that define who I am now.

Firstly, my most significant professional and personal learning comes as a humbling experience. The experiences of working with teachers where I had to suppress my previous behaviours of judging and evaluating teachers opened my eyes to see teachers' practices at ground-zero. Even though I had previously been a teacher, my recent experiences of being a teacher educator have decayed those early experiences from my memory. This research has reminded me of my professional beginning as a science teacher. It reminded me of the endless frustrations, the continuous demands on us teachers, the constant systemic challenges, and the feeling of utter helplessness when seemingly haphazard policies are imposed on us overnight. Now, with this research experience, I move my allegiances to teachers, and I promise to myself that I will champion teachers and raise their voices and expertise in my educational practices and future research. I will continue to research with teachers in the Maldivian context to bring their voices into international platforms so that our little SIDS is not only known for its natural beauty that attracts tourists but also academics to research WITH us locals. I will argue on the importance of locals researching our own context and will promote such research findings to impact how my country can work with donor support in developing our education system.

Secondly, this journey has reshaped my writing skills. Although English is my second language, I considered myself as a capable English writer. But faced with a higher level of academic writing in English and the thought processes associated with it, writing became challenging, frustrating, and painful. Now, I am proud that this research process has enhanced my writing skills and expanded my vocabulary in a way that none of my previous educational training has had.

Lastly, pre-PhD, I tended to value big numbers and statistics in research. I attribute such perceptions to my initial science education background. However, in this learning journey, I have painfully unlearnt my preconceived notion of 'numbers are the best research'. I have engaged with multiple philosophical orientations to enable me to reflect on my existing ontologies and epistemologies and how certain worldviews may bring in prejudices. Painfully, I have learnt to value and see the beauty and colours of rich data and how engaging in such data generation and analysis can be humbling yet empowering. I have questioned and struggled to understand how data analysis can be rigorous without resorting to positivist data analysis strategies. In the process, I have learnt the power of multiple interpretations and how collegial dialogue with a critical friend can open up a 'whole new world'. I am now fascinated by the beauty of this new world of non-positivist research methods. I will endeavour not only to go further in engaging in and exploring such new worlds, but I will also teach, preach, and practice these alternative ways of being, becoming, and researching.

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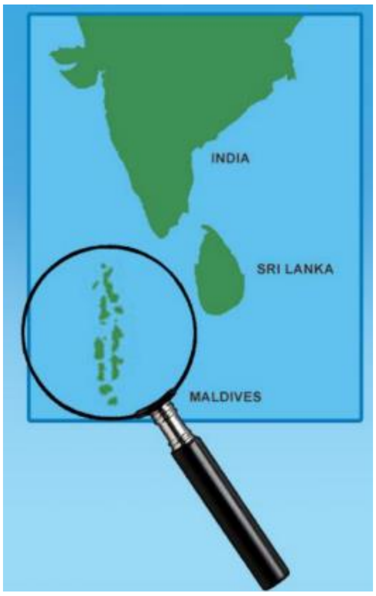
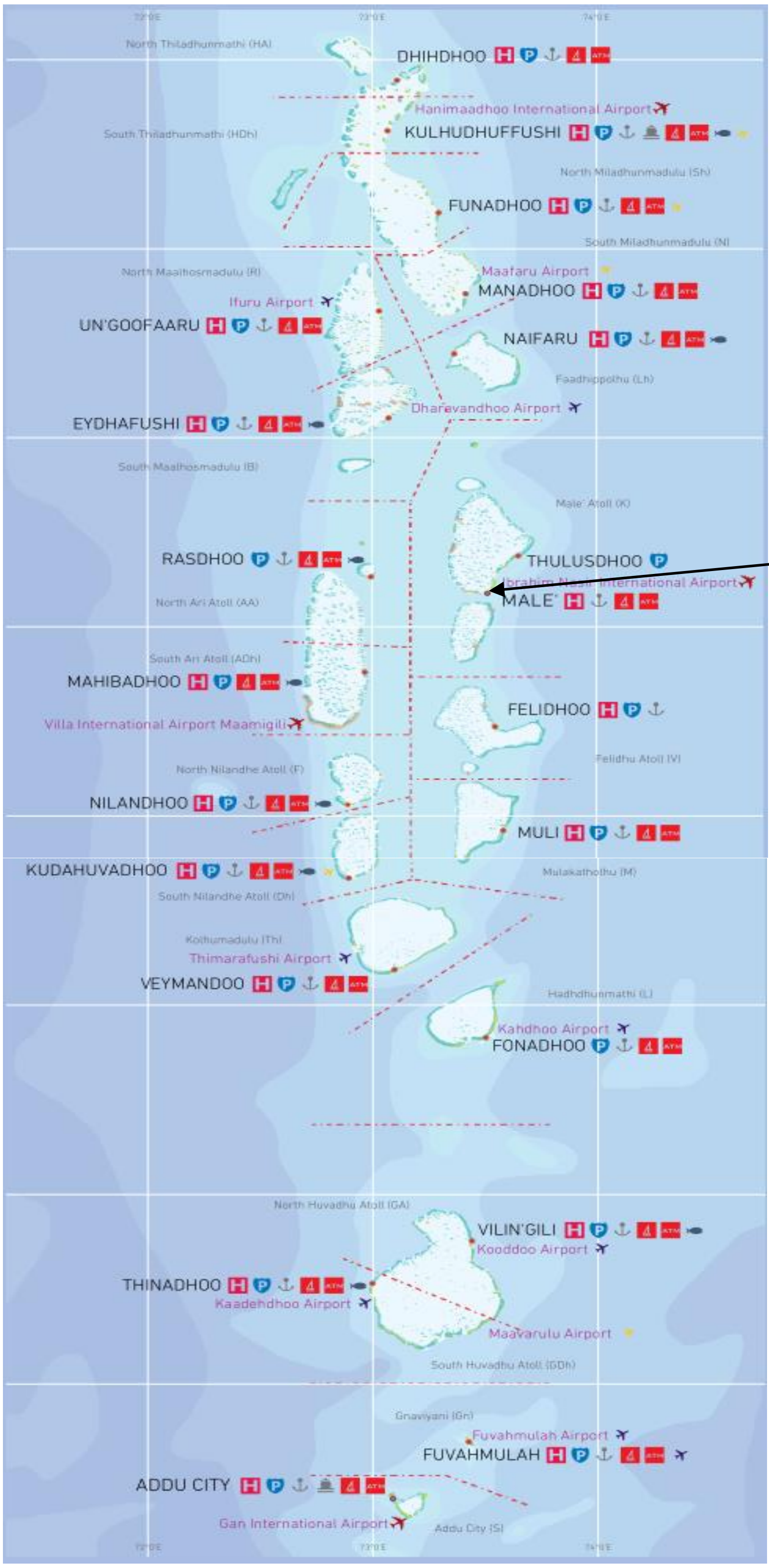
Appendices

A.1 Map of the Maldives

. Source: Ministry of Environment and Energy, 2016)





The capital of Maldives, this study's fieldwork site

A.2 School of Education ethics approval letter

Graduate School of Education
University of Bristol
35 Berkeley Square
Bristol BS8 1JA
Tel: 0117 331 4305
e-mail: Wan.Yee@bristol.ac.uk

25th May 2017

Aminath Shiyama
aminath.shiyama@bristol.ac.uk

Dear Aminath,

Ethical Review: Ph.D Proposal *'Developing Pedagogies for Primary Science Teaching: Role of Science Process Skills in Integrating Environmental Education with Science Education'*.

I am pleased to inform you that your Ph.D proposal has been reviewed according to the procedures of the University of Bristol. It has been ethically approved and you may commence fieldwork.

You remain responsible for ensuring that your research is managed in an ethical way. Please consult your supervisor or Departmental Research Ethics officer if you encounter any ethical dilemmas or difficulties arise as you conduct the research.

Yours sincerely

[redacted]

Wan Ching Yee
Chair of Departmental Research Ethics Committee

A.3 Ministry of Education permission letter

بسم الله الرحمن الرحيم

Ministry of Education
Policy Planning and Research Division
Malé, Maldives

މިނިސްޓްރީ އޮފް އެޑިޔުކޭޝަން
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މާލެ، ދިވެހިރާއްޖެ

<u>To Whom It May Concern</u>

Approval for collecting information from schools in Maldives

This is to inform that Ms. Aminath Shiyama (A-033404), who is doing Ph.D. in Education at the Graduate School of Education; University of Bristol, U.K. has the permission to collect information required for her research project from the schools of Maldives.

Research topic:

Developing Pedagogies for Primary Science Teaching: Role of Science Process Skills in Integrating Environmental Education with Science Education

Main objectives:

To explore the pedagogical potential for primary science teachers in teaching science process skills as an approach to integrate science education with environmental education

Data needed:

Information related to issues in the pedagogical potential for primary science teachers in teaching science process skills as an approach to integrate science education with environmental education.

Participants of the research study:

Selected Grade 5 Science teachers of Key Stages 1 and 2; selected Science Curriculum Developers of Key Stage 1; and selected Primary Science Teacher Educators of Key Stage 1, from schools and educational institutions comprising Malé, Villingili or HulhuMalé, S. Hithadhoo, H.Dh. Kulhudhuffushi, and M. Muli.

Please provide your assistance and support to collect the required information for the research.

4 July 2017

MINISTRY OF EDUCATION
REPUBLIC OF MALDIVES

1

Velaanaage, 9th Floor, Ameer Ahmed Magu, Malé 20-096, Maldives
Tel: 332 3261, 332 3262 Fax: 332 1201

A.4 Phase One – Information sheet, Interview guide with Students work-sample analysis guide & Consent form

Interview Schedule- Semi-structured interview and Recording Sheet

Participant Type: Teacher/Leading Teacher Curriculum Developer Teacher Educator

Participant's Intuition: ……………………………………………………………………………

Preferred pseudonym to use in the research: ……………………………………………

Date:…………………………… **Time:** …………………

Venue:…………………………

Introduction

Thank you (*Insert name of participant*) for participating in my research. Your participation is invaluable for my research. **In no way is this research about evaluating or judging your practice of teaching science, but it is about exploring and discussing your practice.**

Have you read the information sheet and have any questions for me?

Just for clarification what I will refer to science process skills in this interview are skills such as observing, classifying, measuring, predicting, and integrated skills such as investigation. The Curriculum refers to these in the Working Scientifically strand, and specifically has the skills of observation, measurement, and investigating as the key skills. Refer to page 36 of the science syllabus KS2.

Also, what I mean by environment education in this interview is education about, for and through the environment. For example, using ideas about adaptations to explore how this happens in the environment, why and how does these help/benefit the environment.

If you are happy to proceed, **please sign the consent form** and then we can proceed with the interview.

Checklist:

- Information about research provided ☐
- Consent given ☐
- Alias provided/discussed ☐
- Audio recording approved **YES/ NO**
- Will be a participant for the focus group? **YES/ NO**

<table>
<tr><th>Semi-Structured Interview Questions
(key questions are in blue)</th><th>Interviewer Notes</th></tr>
<tr><td colspan="2">A. Participant's background</td></tr>
<tr><td>1. How long have you been a primary teacher/teacher educator?
2. What qualifications or trainings do you have? When were they acquired?
3. Which grades have you been teaching/training over past three years?</td><td></td></tr>
<tr><td colspan="2">B. Current practices of teaching SPS and EE</td></tr>
<tr><td>1. `Let's have a look at the students' work samples you have shared. (If more than one set of work was shared ask to choose one that teacher believes has SPS and/or EE in it).
a. What are the science process skills that was taught in this lesson?
b. What environmental education approaches did you use in the lesson, if any?
c. Can you describe how the lesson was conducted?
d. How did the students react to this lesson?
e. What was the curriculum outcome/indicator for this lesson?
f. How was this lesson planned? What resources did you refer to in the planning?
g. What went well in this lesson you think?
h. What things and how will you improve this lesson for the next time you teach it?</td><td></td></tr>
<tr><td colspan="2"><u>My initial analysis of the students' work</u>
• What skills are represented in the students' work?
• How was it done?
• Is EE incorporated in the lesson? -------------------------- If so how?</td></tr>
<tr><td>2. How often do you get to teach/observe science lessons where there are science process skills emphasized?</td><td></td></tr>
<tr><td>3. Do you think science can be taught using environmental education approaches? Why? /Why not? Describe a lesson where you have done/observed so.</td><td></td></tr>
<tr><td>4. How often do you get to teach/observe science lesson where there are environmental education approaches incorporated?</td><td></td></tr>
<tr><td>5. How often do you teach/observe lessons where there is science process skills AND environmental education approaches are incorporated?</td><td></td></tr>
</table>

6. Do you think you are able to teach/observe the observation, measurement, investigation skills as identified in the curriculum? Can you explain?	
7. Which of these **science process skills** do you think you/teachers are **confident in teaching**? Why?	
8. How do you/teachers assess your students' level of science process skills? How do you/teachers assess their environmental education learning?	
9. For these students in grade 5, what science process skills do you think is necessary to learn? Why? How do you teach these skills? *Prompts*: i. What skills were taught? How was it done? What did you do? What did students do? What was the content of the lesson? How was it planned? What were the student learning outcomes? Any other skills? ii. Any more? Anything else about the lesson?	
10. For these students in grade 5, what environmental education is necessary to learn? Why? How can it be done in the science classroom?	
C. **Challenges and preferred methods/areas of support to teach SPS and EE**	
1. What are the major challenges you/teachers have in teaching science process skills?	
2. What are the major challenges you/teachers have in teaching science using environmental education approaches?	
3. Which of these science process skills are the most difficult to teach? Why? How do you think that be addressed through school professional development support?	
4. If you are to create a professional learning support programme on teaching using environmental education approach and science process skills in your science teaching how would you go about planning and delivering it?	

Check-list before finishing:

- What SPS are being taught ☐
- How is EE incorporated in the science lessons? ☐
- How frequently are they being used/taught? ☐
- Benefits of this (SPS and EE and combined SPS and EE) to the students. ☐
- Challenges of teaching SPS, EE and combining them in teaching. ☐

RESEARCH-PARTICIPANT CONSENT FORM

Name of Researcher: *Aminath Shiyama*

Email address : *aminath.shiyama@bristol.ac.uk*

Phone no: *+9607797333 (in Maldives) , +447415985850 (in UK)*

Title of study:

Exploring Pedagogies for Primary Science Teaching: The role of science process skills in integrating environmental education with science education

Please read and complete this form carefully. If you do not understand anything and would like more information, please ask.

• I have had the research satisfactorily explained to me in verbal and / or written form by the researcher.	**YES / NO**
• I understand that my participation in this research involve:	
• *an interview regarding my science teaching practices,*	**YES / NO**
• *including providing 3 of my students'-work samples of my choice.*	**YES / NO**
The interview will be audiotaped, and it will take about 45 minutes.	**YES / NO**
• I understand there will be a follow-up focus-group interview with other participants in this study at a later date. I would like to participate in it.	**YES / NO**
• I understand that participating in this research is voluntary and I may withdraw from this study at any time, ***before October 2017***.	**YES / NO**
• I understand that all information about me will be treated in strict confidence and that I will not be named in any written work arising from this study.	**YES / NO**
• I understand that any information that I provide will be used solely for research and academic purposes only.	**YES / NO**
• I understand that the researcher will be discussing the progress of the research with other academics such as the research-supervisors.	**YES / NO**

I freely give my consent to participate in this research study and have been given a copy of this form and the information letter.

Participant Signature: ………………………………………………………………………………………

Name: ……………………………………………………… **Date:** ……………………………………………………

A.5 Phase Two – Information sheet

PARTICIPANT INFORMATION SHEET

Exploring Pedagogies for Primary Science Teaching: Teaching science process skills through environmental education

Introduction: I am a PhD student at University of Bristol, pursuing a PhD in Education. My proposed study aims to explore the development of primary science pedagogies through teaching Science Process Skills to integrate Science Education with Environmental Education. As a KS2 science teacher I would like to invite you to participate in this project. First I would like to explain why the research is being done and what it will involve.

The purpose of this study is to ***explore and develop primary science pedagogy in teaching science process skills through environmental education.*** This is a collaborative research where you as the participant will be a **co-researcher**. This means there will be a long-term commitment to work collaboratively with the researcher on specific research related tasks, which will be explained in detail prior to the task. The researcher will be closely and collaboratively working with you on planning your science lessons over term 1 2018 and you are requested to participate through discussion meetings, individual interviews, classroom observations and peer planning and observation sessions.

Do I have to take part? Participation in this research is **voluntary.**

1) All the research-related activities will be conducted during the school time.
2) As this is a collaborative research, your input as professional teachers is imperative in the success of this research and thus.
3) Classroom observations will be based on lessons which are pre-agreed on. All interviews will be audio-recorded and you can speak either in English or Dhivehi. I also request from you to provide me with 3 students'-work samples, from the lessons that will be observed.
4) I will work with you as a whole group, smaller sub-groups and with individual teachers.
5) As the data collection will be long-term, after each topic, I would like to involve you in data-analysis steps either individually or as a group. This is important for further data collection.

Ownership of the materials developed: As this is s collaborative research and I hope through the process we will be co-producing various resources for science teaching. These materials will be published, with due credit to the teachers who produced them. As such your name will be published on these resources.

Will my taking part in this project be kept confidential? Apart from the documents/resources that are co-produced as part of this research, other information such as interview data, observation data will be anonymised in the reporting of the research so that the information you provide cannot be traced back to you. I will use pseudonyms to ensure anonymity and store your data in a secured password protected computer. In reporting the findings from this research as publications or conference presentations, I will take care to ensure that no individuals or schools can be identified.

What happens now? If you are interested in taking part in the study we will together sign the attached contract which explains our roles in this research. You can withdraw your participation before September 2018. You will not be judged in any way on any of the information you choose to disclose and I would ask you to be as honest as possible.

Who can I contact if I have any concerns about the research process? If you have any concerns that I cannot resolve, or any complaints, you may contact my supervisor.

Researcher	Aminath Shiyama	email- aminath.shiyama@bristol.ac.uk
Supervisor	Dr. Angeline M. Barrette	email: angeline.barrett@bristol.ac.uk

A.6 Phase Two – Consent/Contract

RESEARCHER & CO-RESEARCHER (PARTICIPANT) AGREEMENT

Title of study:
Exploring Pedagogies for Primary Science Teaching: The Role of science process skills in integrating environmental education with science education

Name of Researcher: *Aminath Shiyama* ***Name of Co-Researcher**: ………………………………*

Contact no: *+9607797333 (in Maldives)*
+447415985850 (in UK)
Contact no: ………………………………………………

We both agree to the following roles.

The Researcher's roles

- To work in collaboration with the co-researcher in the process of gathering data for the purpose of this research.
- Discuss the data that is being collected and explain the way the research related activities are going (collectively working on the data-analysis and interpretations).
- Observe the co-researchers' pre-agreed lesson, participate in the coordination meetings and provide support in science teaching related activities in the school. These will form basis for the data for this research.
- Give due credit the co-researchers' for any materials they produce as part of this research and provide ownership to these materials so that they can use them and share them.
- Data from the interviews and observations will be anonymised in the reporting of the research.

Co-researcher's roles

- Voluntarily participate in this research which involves collaboratively working with the researcher and my colleagues.
- Work with the researcher and my colleagues on various data collection activities associated with this research (researcher observing my lessons, observing lessons of my colleagues and providing them feedback, participate and collaboratively develop teaching resources for my science lessons)
- Discuss with the researcher on my professional learning associated with working on this research.
- Work in producing teaching resources which will have my name on it when they are published. I can freely use and share these resources.
- I understand data from the interviews and observations will be anonymised in the reporting of the research.

Researcher Signature: …………………………… **Date: ………………………………………………**

Co-researcher Signature: …………………………… **Date: ………………………………………………**

A.7 Phase Two - Interview and goal-setting prompts

First Interview

1. What does science process skills mean to you? How important is it in the teaching of science?
2. What does environmental education mean to you? How important is to incorporate this in science teaching?
3. In the current curriculum science process skills are identified in the Working Scientifically Strand. How do you teach the outcomes and indicators of this strand? How do you assess them?
4. What are the areas of your science teaching that you want professional support on? What goals would you set for your learning? How will you follow it through?

(Complete attach goal setting form during interview)

Second & Third Interview

1. How is your teaching now with regard to science process skills and environmental education?
2. What new things have you learnt about this? About your own practices?
3. What are some things you would like to still explore and what goals will you set for yourself and how will you follow it through?

(Complete attach goal setting form during interview)

Fourth Interview

1. How has your own understanding of science process skills changed over the course of this research involvement period?
2. How has your teaching of science process skills over the course of this research involvement period?
3. How has your own understanding of environmental education changed over the course of this research involvement period?
4. How has your teaching of environmental education over the course of this research involvement period?
5. How has your understanding and implementation of the Working Scientifically Strand from the curriculum changed over this time?
6. How would you describe your learning during this period of working on this research?
7. What are the most significant things that you have learnt?

Interview goal setting discussion notes (for 1st, 2nd and 3rd individual interviews)

This is used to help set collaborative goals and make each other's expectations, support clear

This will be filled during individual interviews and discussions with the researcher.

Date: **Participant (co-researcher):**

Goal setting duration:

Researcher goals and expectations	**Co-researcher goals and expectations**
Review of goals from before	
New goals and directions	

A.8 Phase Two- Classroom lesson observation protocol

Pre-Observation Questions

- What is the topic and focus skills that will be taught today?
- What topics has this class covered recently?
- What do you anticipate doing in the class today?
- What have you done to prepare for this lesson?
- What do you expect students to learn during this lesson?
- What, if anything, should I know about the students in this class?

Post-Observation Questions

- How did this lesson turn out compared to what you planned? What, if any, differences occurred? W
- What SPS was taught do you think? How was it conducted?
- How was EE incorporated in the lesson?
- How was SPS and EE integrated in the lesson
- How typical was this lesson for your students?
- What do you think the students learned from this lesson, and what do they still need to learn? What causes you to say that?
- How do you think this lesson will be taught if you do it next time? How else would you change your preparation? Content understanding?
- What follow-up experiences will students receive and what are the important science concepts the students will learn? How will you ensure this is achieved (in the follow up lessons)?

A.9 Phase Two – Excerpt from professional learning activities log

The beginning

Teacher	18-Jan-18	23-Jan-18	06-Feb-18	07-Feb-18	20-Feb-18	22-Feb-18	27-Feb-18	28-Feb-18	28-Feb-18	06-Mar-18	03-Apr-18
	My first Group meeting - intro and induction of my research	planning discussionf with Sci coordinator	**Coordination meeting 1**	Individual meeting	**Coordination meeting 2**	e-mail commnication sharing/co-producing resources	helped teachers on themetising exercise	e-mail commnication sharing/co-producing resources	**classroom observations 1 - for all**	coordination meeting - I DID NOT ATTEND	**Coordination meeting 3**
LT	major role, leading		Present		Present		Present		teachers competence.		Present
Dheena	Present	Present - planning mostly for week ahead and my research related activities	Present		Present	email communication regarding assesment task	Present	email communication re photosynthesis lab work	Done		Present
Dhasya	Present		Present		Present		Present		Done		Present
Dhunya	Present		Present		Present		Present		Done		Present
Dhaliya	Present		Present	Interview on her teaching of SPS and EE practices	Present		Present		Done		Present

The middle

Teacher	05-May	06-May	07-May	07-May	08-May	09-May	10-May	12-May	13-May	14-May
	research oriented training	meeting for planning - working on goals	**classroom observations 3 - weathering lab**	**post-discussion**	**post-discussion**	research oriented training			Meeting planning	observe topic start with Dheena and Dhalia
LT										
Dheena	communicating about her research work, feedback and discuss- emalil comments		present		present		chlidrns' day, I did not join school though they invited me for celebrations…was good to share this preps with teachers	qual assign help and discusion	discussion for topic planning - see pic on this day..good plan for ramadan time..	did - check notes and pics
Dhasya			present	present	present	helping with her research work - data anysis interrater reliability				
Dhunya			present		present					
Dhaliya			present	present	present	helping on her biology content upgrade		biowork, went to schoo to go through the wrksheets, talked about possible ways of helping as PD, my research		did - check otes and pics

The end

22-Jul	23-Jul	24-Jul	25-Jul	29-Jul	30-Jul	31-Jul	01-Aug	02-Aug	02-Aug	04-Aug	05-Aug
					interview Haula (LabTech) - Good one	maus b'day was celebrated after school and disrupted my interview plans:(				Helped Shahula with her lesson plans for TP..good time to bond and sharing experiences.Did her TT lesson plans	
								Final interviews done	Group interview on obseervation and feedback with SHAHULA		
						Final interview - half done					
						Final Interview done	planned to do composting lesson observation..DID NOT				
did not go to school			visited school on school anniversary and arranged meeting next week	was a holiday in the last minute decision					Group interview on obseervation and feedback with SANA		**Final interviews done**

A.10 Phase Two – A sample of our co-produced student worksheet

11- Complete the table below

Name of the cell	Draw	One Function.

12- Fill in the blanks.

a- Cell division occurs in ____________organisms.

b- The function of nerve cell is to_____________

c- Photosynthesis is____

____

____

____

13- Draw and label the parts of a plant cell.

14- Fill in the table.

Body system	Functions	Organs in it	Diagram
Digestive system			
Circulatory system			
Skeletal system			
Nervous system			

15- Write the part of the plant which helps in

a- Reproducing-______________________

b- Food production-___________________

c- Absorbing water and nutrients-______________

d- Absorbing air-______________________

16- Explain why we get breathless when we run for a long time.

____

Grade 6- GENERAL SCIENCE

Answer the questions

1- Is a *bat* or a *hat* is a living organism? Give in 2 reasons to justify your answer.

____

____

____

2- Explain how you can use only *observations skills* to explain that living things grow.

____

____

____

3- Classify the following living things to unicellular or multicellular organisms.

flower dolphin virus snake tuna bacteria human owl fungus

Unicellular organisms	Multicellular organisms

4- Name 2 kingdoms of living things and give one example for each.

____

____

5- Complete the flow diagram below with 2 examples of plant.

Plants

6- Are plants living things? Give 2 reasons.

____

____

7- Write down the basic needs of living things in order to survive.

____

8- What is meant by *multicellular organisms*?

____

9- Write a difference between a unicellular and multicellular organisms.

____

____

10- Draw the a unicellular organism, and give the name of the Kingdom to which it belongs.

A.11 Phase Two – Sample lesson plans

Sample lesson plan 1– investigating photosynthesis

LESSON PLAN – GRADE 6 / 2018

Subject: General Science	**Period:2**	**Class: 6C**
Strands. Photosynthesis Experiment		**Week 17**

Outcome: LL1.4 Identifies that multi cellular organisms have specialized structures and systems to perform basic functions of life.

WS2.1 Conducts simple investigations.

WS3.1 Take care of themselves, others and respects others viewpoints.

Learning intensions

- The students will be able to:-
  - follow the instruction of the experiment and complete the data needed to come up with a conclusion.

Success criteria

_ **I will be success if I**

- Can follow the instruction and come up with a conclusion from the experiment based on weathering.

Materials; pupils book, worksheet ,lab apparatus, materials for the experiment, question worksheet etc.

Pre-requisites:

-know the different components needed for photosynthesis.

-What is photosynthesis?

Procedure:

Set induction:

- Show two different types of leaves. A variegated leaf and a green simple leaf. Ask them if they do a starch test with both the leaves, what would happen?
-

Main Activities:

- Show the materials and give instructions to follow the experiment.
- Explain the safety measures, variables, how to fill the question worksheet etc.
- Carryout the experiment and help the students to fill the data.

For average/gifted students :

- They can help to draw and color the changes that took place with the leaves with iodine?

For students with learning difficulties

- Take the data readings according to the leaders in the group and can participate in making the charts afterwards.

Closure/ Lesson Evaluation:

- Teacher will check their work in the worksheet and all come up to a conclusion.

Follow –up/ homework	Those students whose readings are inappropriate let them rewrite the corrected readings.
Self-Reflection	Explain further the doubts they have regarding the experiment.
Leading teachers note:	

Sample lesson plan 2– investigating weathering

LESSON PLAN – GRADE 6 / 2018

Subject: General Science	Period:2	Class: 6C
Strands. Activity on weathering.		**Week 17**

Outcome: EB1.4: Studies factors that influence weather and climate systems

Indicators: This is evident when the student:

a. Identifies factors that influence weather and climate systems (e.g., temperature, wind, air, moisture, pressure, the sun).

Learning intensions

- The students will be able to:-
  - follow the instruction of the experiment and complete the data needed to come up with a conclusion.

Success criteria

_ **I will be success if I**

- Can follow the instruction and come up with a conclusion from the experiment based on weathering.

Materials; pupils book, worksheet ,lab apparatus, materials for the experiment etc.

Pre-requisites:

-know the different types of weathering.

Procedure:

Set induction:

- Ask them about the two different types of weathering to recall the memory on the lesson taught previously.

Main Activities:

- Show the materials and give instructions to follow the experiment.
- Explain the safety measures, variables, how to fill the worksheet etc.
- Carryout the experiment and help the students to fill the data.

For average/gifted students :

- They can help to lead the experiment in taking the weight, helping others in the groups to follow the experiment etc.

For students with learning difficulties

- Take the data readings according to the leaders in the group.

Closure/ Lesson Evaluation:

- Teacher will check their work in the worksheet and all come up to a conclusion.

Follow –up/ homework	Those students whose readings are inappropriate let them rewrite the corrected readings.
Self-Reflection	Explain further the doubts they have regarding the experiment.
Leading teachers note:	

A.12 Phase Two – Sample of our co-produced investigation template/worksheet

One of the initial ones we used

Grade 6: Investigating weathering

Investigation Question? What factors affect weathering and erosion?

We are going to explore weathering of calcium carbonate and how factors such as temperature and chemicals can affect it.

We will use the following materials:

For All the groups:	Per group:
• 2 pieces of chalk • 2 test tubes	• 20 ml water and 20 ml vinegar OR • 20 ml of cold water and 20ml of water at room temperature

Based on the materials you have got, you will be investigating the **effect of** either **temperature** or **chemicals** on weathering.

Using this information and the materials you have got in your group, **make a prediction and hypothesis**. What do you think will happen…and why (***use scientific reasoning to explain why***)

I predict that ……………………………………………………………………

because ……………………………………………………………………

When you are conducting investigations, you need to identify the variables in your investigations.

Variables are factors that will affect your investigation, such as temperature, time, mass and so on.

- In your investigation, you are changing or investigating one factor and its effects. This is called an **independent variable.**
- The variable you are going to measure/observe is called the **dependent variable**.
- Some variables must be kept SAME to make the investigation a fair test and your results valid. These are **controlled variables**

What will change when doing the investigation?	What will be measured when doing the investigation?	What will stay the same when doing the investigation?
When doing the investigation **we will change:**	When doing the investigation **we will measure/observe:**	When doing the investigation **we will keep these things the same:**

Procedure:
Write the steps for your investigation. Draw a diagrammatic representation of the procedure too.

Record your results:

	Mass/length of chalk **before** (or observations)	Mass/length of chalk **after** (or observations)
Test tube1 (vinegar/water at room temp)		
Test tube 2 (water/ice water)		

What is the result showing? Write it in words.

What was the factor you investigated? ……………………………………

Does this represent chemical or physical weathering? ……………………………

Based on your results, make a conclusion: (*respond to your hypothesis*)

Get the conclusion from another group who investigated a different factor than your group. What are their conclusions?

Based on what you have learnt here, what are some factors that affect weathering and erosion?

Our revised version

Investigation plan

Researchable Question:

What happens to ______________________________ when we change ______________________________ ?

Hypothesis:

I predict that ______________________________ because ______________________________

Fair Test:

Change one thing	**M**easure or **O**bserve one thing	Keep all these things the **S**ame

Procedure:
Write the steps for your investigation.
Would anyone who reads these instructions be able to do the experiment properly?
Include a labeled diagram to show how you will set it up.

1

Results: (record what happened)

Group results:

Soil type	**A**	**B**	**C**
Water added (ml)			
Water drained			
Water retained			
Water retention%			

Class results: Water retention percentage

Group no	A	B	C
1			
2			
3			
4			
5			
6			
Average			

Conclusion: (respond to your hypothesis)

Our investigation showed that:

Making inferences
Which of these soil samples would you use for the following? Give a reason.

Use	Soil type/sample	Why
Planting trees		
Decorating outdoor areas of homes		

2

A.13 Phase Two – PowerPoint slides used in one of the demonstration-lessons

INVESTIGATING SURFACE TENSION OF WATER

PRACTICING THE SCIENCE PROCESS SKILLS

18 JUNE 2018

INVESTIGATING – POSING A PROBLEM

Activity 1: - Making a Prediction
How many drops of water can you fit on a coin?

Equipment:
Dropper, coin, cup of water, plate, paper towel

Test several times and record your results.

What can you conclude?

INVESTIGATING – POSING A PROBLEM

In this activity with water drops, what are the **variables** that could change the number of drops?

Make a list.

INVESTIGATING – MAKING A RESEARCHABLE QUESTION

A Research question
highlights one variable to be changed and one variable to be measured:

what happens to the number of water drops

when we change __________?

Make a hypothesis now based on the research question and the variables:

Researchable question	***Hypothesis***
What happens to the growth of the plant **when we change** the amount of sunlight?	The plant won't grow as tall in the cupboard **because** plants need sunlight.
What happens to the amount of water that soaks in **when we change** the type of soil?	Black soil will hold more soil than sand **because** it has smaller particles to trap the water.

Designing a 'fair test': Defining Variables

Cows **M**oo **S**oftly:

Change one thing
Measure or **o**bserve one thing
Keep everything else the **S**ame

DESIGNING A 'FAIR TEST': DEFINING VARIABLES

Change one thing	Measure or Observe one thing	Keep all these things the Same

---

INVESTIGATING

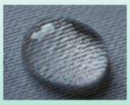
Activity 2:

- Select one variable from the water drop test
- **Plan an experiment** to test the effect of changing that variable
- Write a plan for your experiment *before* you start
- **Record your results** and present them
- What **conclusions can you infer** from it**?**
- What is the science behind
- What else can you explore more on this

Reflect on your investigations

- What are some of the things that affected the accuracy of your investigation?
- How can you improve on the experiment you carried out?
- How would you use this process in your classroom?

THE SCIENCE: SURFACE TENSION OF WATER



- Water molecules attract each other and tend to stick together.
- This property results in **surface tension**.
- Because water molecules at the surface of the water puddle attract more to one other than they do to the air molecules above them, **they cling together** and form a dome shape on the coin.
- Surface tension prevents the water molecules from falling out and spilling.
- You can keep adding water drops until the surface tension is not strong enough to counter the gravitational pull on the water.

TEACHING SCIENCE PROCESS SKILLS

What does *teaching* the process of science mean to you?

- Analysis of data – observation, interpretation, inference to natural world (collection, analysis, interpretation)
- To cultivate the ability to be open to creativity, intuition and surprise in science
- Provide opportunities to do science: exploring, engaging in discovery, interpretation—instructor as facilitator
- Role of community – coming to understand that science is not done by individuals but done by a community
- Telling stories that are constrained by data
- Model the wonder, the inquiry, the excitement of science and then engage them in doing this as well.
- Using failure to create an opportunity to learn in a positive way.
- How do you fit the opportunity to experiment and fail into time constrained and curricularly constrained courses.- role of personal stories of great icons. Making the canned open ended.

TEACHING SCIENCE PROCESS SKILLS

What do we really want our students to be able to *do* that can help us define what and how we teach about the process of science?

- Affective changes
  - Trust that there is a distinction between scientific arguments and other kinds of arguments – and scientist trained to carry out this kind of analysis
  - Increased confidence in scientific argument
  - Understanding and comfort with uncertainty inherent in scientific argument
  - Understand and be comfortable with the messyness of science.
- Wonder about why is it that way (in the natural world)? And have some idea about how to start to answer this question scientifically or through observation.
- Being able to have an idea or experiment or strategy fail, learn from this and try again.
- Understanding the difference between a narrative and a scientific presentation—(problems removed) and be able to develop a scientific argument from a set of data.

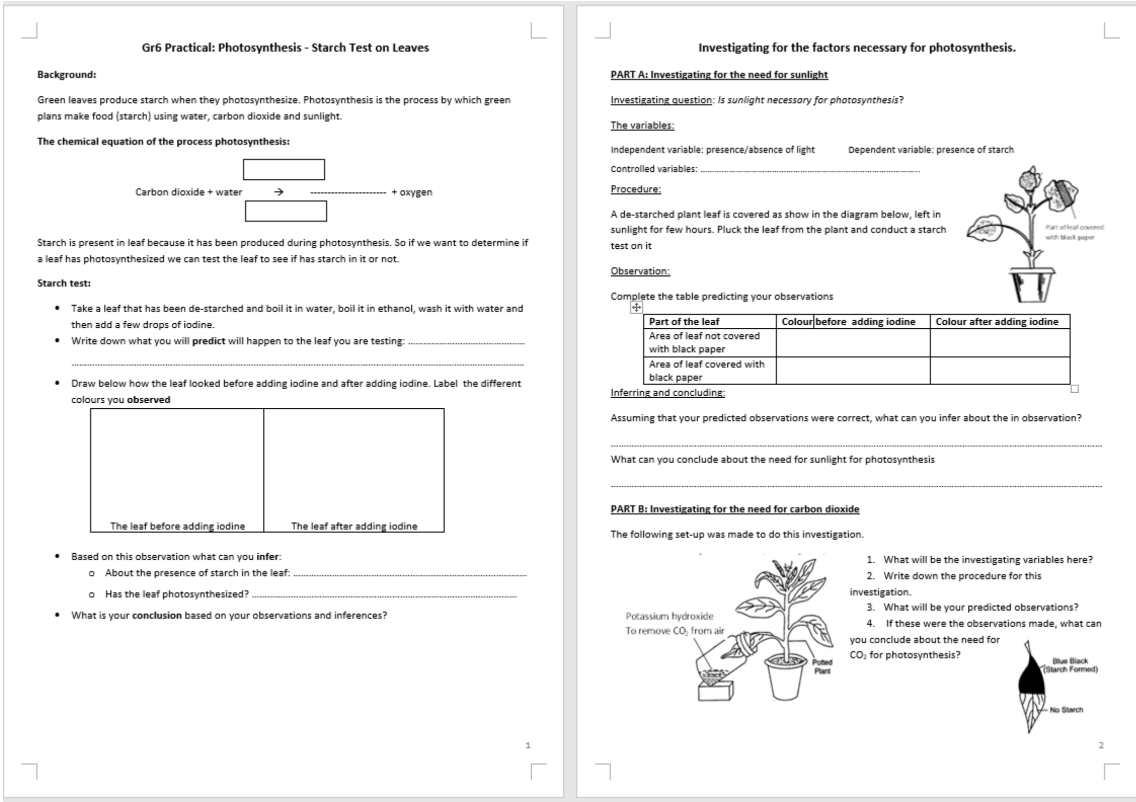
A.14 Phase Two- Sample lesson observation notes

Lesson: Starch-test for photosynthesis

Pre-Observation discussion:

I emphasized that observation is a key skill student will be making and Dhasya expressed that she has not seen the worksheet/investigation sheet that I had produced, so she was not well prepared for the lesson. So, she will be seeing it first time herself as she is teaching it.

This is the worksheet we had decided to use for this lesson. This was circulated via email to all participants.



Gr6 Practical: Photosynthesis - Starch Test on Leaves

Background:

Green leaves produce starch when they photosynthesize. Photosynthesis is the process by which green plans make food (starch) using water, carbon dioxide and sunlight.

The chemical equation of the process photosynthesis:

Carbon dioxide + water → -------------------- + oxygen

Starch is present in leaf because it has been produced during photosynthesis. So if we want to determine if a leaf has photosynthesized we can test the leaf to see if has starch in it or not.

Starch test:

- Take a leaf that has been de-starched and boil it in water, boil it in ethanol, wash it with water and then add a few drops of iodine.
- Write down what you will **predict** will happen to the leaf you are testing: ....
- Draw below how the leaf looked before adding iodine and after adding iodine. Label the different colours you **observed**

The leaf before adding iodine	The leaf after adding iodine

- Based on this observation what can you **infer**:
  - About the presence of starch in the leaf: ....
  - Has the leaf photosynthesized? ....
- What is your **conclusion** based on your observations and inferences?

1

Investigating for the factors necessary for photosynthesis.

PART A: Investigating for the need for sunlight

Investigating question: *Is sunlight necessary for photosynthesis*?

The variables:

Independent variable: presence/absence of light   Dependent variable: presence of starch

Controlled variables: ....

Procedure:

A de-starched plant leaf is covered as show in the diagram below, left in sunlight for few hours. Pluck the leaf from the plant and conduct a starch test on it

Observation:

Complete the table predicting your observations

Part of the leaf	Colour before adding iodine	Colour after adding iodine
Area of leaf not covered with black paper		
Area of leaf covered with black paper		

Inferring and concluding:

Assuming that your predicted observations were correct, what can you infer about the in observation?

....

What can you conclude about the need for sunlight for photosynthesis

....

PART B: Investigating for the need for carbon dioxide

The following set-up was made to do this investigation.

1. What will be the investigating variables here?
2. Write down the procedure for this investigation.
3. What will be your predicted observations?
4. If these were the observations made, what can you conclude about the need for CO_2 for photosynthesis?

2

Observation notes:

- *The initial instruction was not clear as she straight jumped into the activity without going through the investigation approach and discussing the aims of the investigation, hypothesis or variables.*
- *Instruction on the activity, the procedure was discussed, students grouped and asked to complete the activity.*

- The worksheet/investigation sheet was shared with students after the activity.
- Overall focus of the lesson was only on observation skills
- Student questioned 'what is infer?' and Dhasya seems to not have understood this term as inference and replied that it was a typo and must have meant 'info'.
- Closed the lesson by discussing each group's conclusion to PartB (Q4). But she did not bring the lesson together (tie-in I together at the end). Questions asked did not focus on skills, but on content.

Post-Observation notes:

- It seems that overall conceptual understanding of Dhasya is minimal here, and there is no focus on the skills at all.
- Discuss in feedback with Dhasya how the skills are incorporated into the investigation.

Post-Observation reflection and discussion:

As I was seeing a big mismatch between what was planned and what was being implemented, during the lesson I felt I should help (assumption was that if I showed Dhasya some ways in which skills can be emphasised in the lesson, she would be able to follow my lead and then maybe implement it herself later) I asked if she wanted me to help with the instructions, specially at the conducting the procedure and observation stages. Dhasya replied that since I was familiar with the worksheet, she would prefer some input from me. So, I helped with some groups in setting up their equipment, instructing with the procedure and making the observations. Though I did not lead the lesson, I felt that this input to the students was helpful in their skills development and Dhasya acknowledged that she was not familiar with the procedure so my input to the lesson was beneficial to her and the students.

Note for me:

One way to avoid this and to make sure the teachers are clear of the procedure and the skills associated, next time I will discuss the worksheet, investigation process, the associated skills and better get the teachers to try it, complete the worksheet. I will try to conduct the lesson for the teachers.

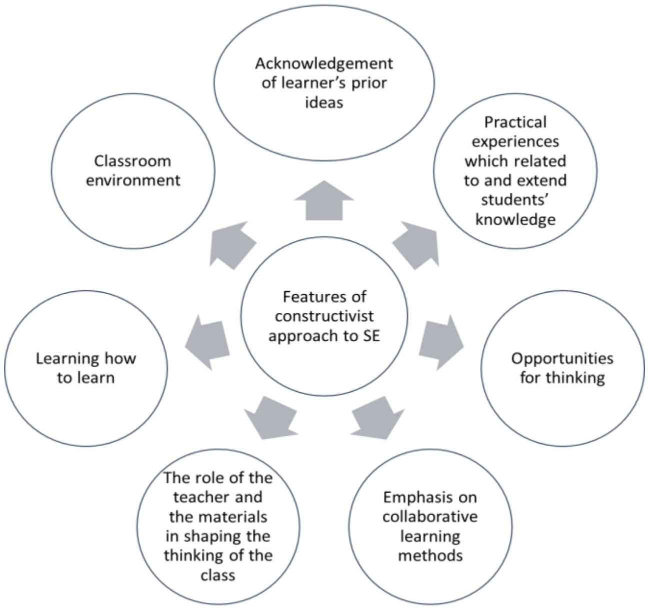
A.15 Phase Two – Research lesson designing template

Teacher-led Classroom-Research

Objective:

Working on a small-scale short-term research with teachers on SPS pedagogies.

Theoretical ideas



Research Focus

Planning, conducting and reflecting a science topic/lesson that was explicitly planned based on these constructivist elements. Possibilities: investigation lesson, PBL lesson

Developing Research Question

Example , How can I use cooperative learning in my science class to improve student learning?

What is your research question?

What evidence will be used to collect data to answer the research question?

How will you collect this evidence?

How will you use this evidence to answer the research question?

A.16 Phase Two – Dheena's research lesson data sample

Investigation plan

Researchable Question:

What happens to ~~the coin~~ the drops when we change the side of the coin?

Hypothesis:

I predict that 5 drops because I didn't know It can hold much water

Fair Test: (Cows Moo Softly)

Change one thing	Measure or Observe one thing	Keep all these things the Same
The ~~the~~ side of the coin	The ~~the~~ number of drops	The ~~the~~ coin stays the same.

Procedure:

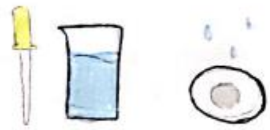
Write the steps for your investigation.

Would anyone who reads these instructions be able to do the experiment properly?

Include a labeled diagram to show how you will set it up.

Step 1:

first we put the coin on the petridish.
Next we used a dropper and counted how many drops of water the coin can hold.
We did this three times.
Then we divided the a amount of drops in total by 3.



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[redacted]

Results: (record what happened)

Emblem side of the coin

	Number of drops
1	44
2	46
3	56
Total	146

=48

Number side of the coin

	Number of drops
1	46
2	47
3	42
Total	135

=45

3)146 = 048
12
026
24
02

3)135 = 045
12
015

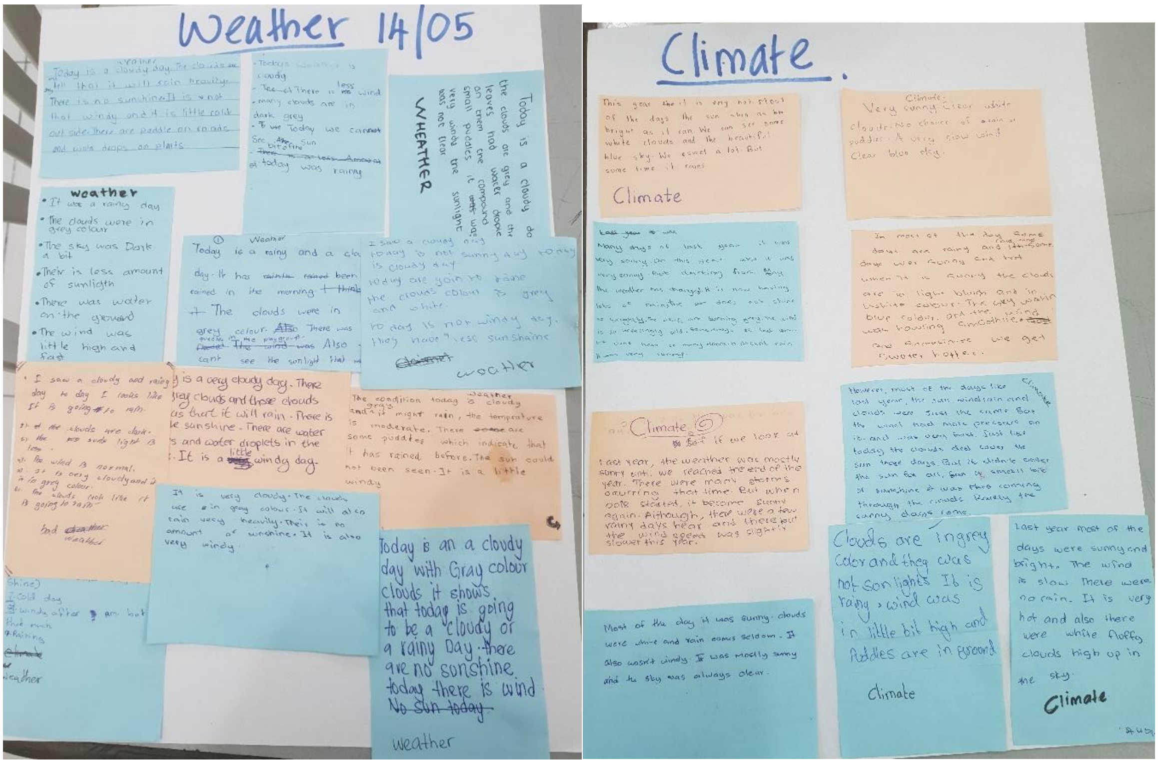
Conclusion: (respond to your hypothesis)

We *proved / disproved* our hypothesis (circle one).

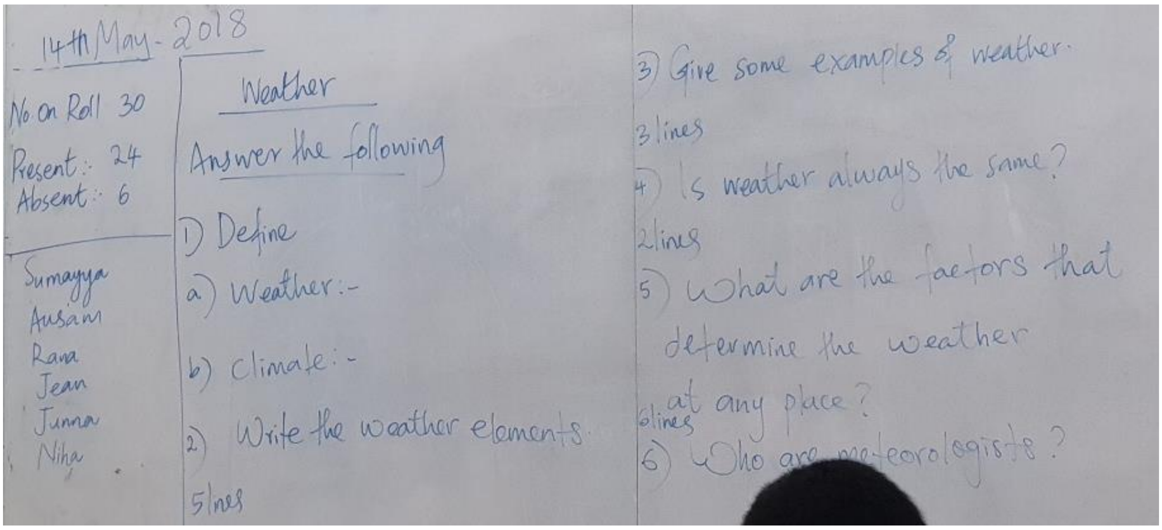
Our investigation showed that:

Water droplets adjoin toghether and holds toghether which is a property of water It is called Surface tension.
More water is colleced than predicted.

A.17 Phase Two- Further comparison of Dheena's and Dhalia's science teaching



Dheena's students' sample of work (A group activity – differentiating observations into weather and climate)



Dhalia's assigning work for students (Individual, answering questions)

A.18 Phase Two – Peer- observation guide

SPS Classroom Observation

Date _____________ Teacher ____ Grade Level 6

Observer ______________________ Lesson Topic ________________ Period: __________________

PRE-OBSERVATION DISCUSSION

Discuss with the teacher briefly the focus of the lesson and note the main key SPS and pedagogies

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

OBSERVING THE TEACHER

As you observe the teacher focus on the following aspects and comment on how the teacher performs them in relation to SPS.

Write examples as much as possible

Aspects to observe	**Notes from observations**
Giving instructions regarding the lesson and associated investigation	
Is it clear?	
Is it connected to each component of the lesson?	

Are the roles of the teacher and students clear?	
Any other aspects of interest to note?	
Student's level of input to the development of the problem initially	
Teaching of the SPS	
What skills were focussed*? (Also you can circle from the list below)	
How clearly were the skills focussed?	
Is it clear which skills were being focussed?	
How are these skills connected to the content?	
Any other aspects of interest?	

GENERAL NOTES FROM THE OBSERVATION

POST- OBSERVATION DISCUSSION

* List of SPS

Observation (OB), Classification(CS), Measurement and use of number(MN), Making Inference(MI), Making Prediction(MP), Communications(CM), Using time and space(UTM), Interpreting data(ID), Defining Operationally(DO), Controlling Variables(CV), Forming Hypothesis(FH), Experimenting(EX)